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An Analysis of Ohio's Forest Resources

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Abstract

This report includes an analysis of the results of the third survey of Ohio's forest resources and trends that have occurred between surveys. Topics include forest area by ownership, stand size, and forest type; timber volume by species, location, and quality; biomass; timber products output; and growth and removals. Nontimber forest resources and uses—water, soil, coal, recreation, and fish and wildlife—are also discussed. Timber volume is projected over the next 30 years, and forest management opportunities that will improve the condition of Ohio's forests are identified.

Cover photo—Majestic forests such as these are found in Ohio's Hill Region.

An Analysis of Ohio's Forest Resources

Contents

Highlights

Total forest land increased by 7.4 percent (490,000 acres) since 1968; this included a 5.5 percent increase in commercial forest area.

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Ohio's forests are maturing; there are more pole and sawtimber stands now than in 1968.

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Timber volumes also increased significantly—48 percent, since 1968. Net growth has been more than three times removals for the period between surveys.

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Timber quality has improved; sawlog quality has improved, and the percentage of timber considered cull has decreased.

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Even though conditions have improved, forest management opportunities still exist: timber quality and species mix, wildlife habitat, recreational opportunities, and esthetic values can all be improved through forest management.

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Forest Surveys of Ohio

The USDA Forest Service, in cooperation with the Ohio Department of Natural Resources, Division of Forestry, periodically inventories the forest resources of Ohio. Two previous inventories were conducted in Ohio and provide data for 1952 and 1968.

This report presents an analysis of the resource data from Ohio's third forest inventory conducted during 1977-79. Statistical data is published in "Forest Statistics for Ohio—1979" (Dennis and Birch 1981). The statistical report also contains information on inventory procedures and an explanation of methods used to compare results of the periodic inventories. A copy of the statistical report will be useful in following this analysis.

Background

Prehistoric Indians, who we now call Hopewell, were the first known inhabitants of Ohio. These people built burial and effigy mounds and left other remains that describe their culture. Although once a flourishing culture, all that remained when the white man arrived were the mounds and artifacts. Even the Eries, who later occupied the shores of Lake Erie, had been exterminated by the Iroquois before the arrival of the first Europeans. The Iroquois word for fine or good river is Ohio. The Ohio River has played an important role in shaping the state's history.

The French were the first Europeans to see Lake Erie and probably to explore the Ohio River. Louis Jolliet, a fur trader, was on the shores of Lake Erie in 1669, and the French explorer Rene Robert Cavelier is believed to have discovered and explored the Ohio River around this same time. Later, English fur traders arrived from New York, and friction developed between the two Nations. Carolina, Virginia, and Pennsylvania traders appeared in the early 18th century, and rivalry for control of the Ohio River produced the first clashes of the French and Indian War in 1754. The French gained dominance of the Ohio Valley but were ultimately forced to cede the whole northwest to Britain.

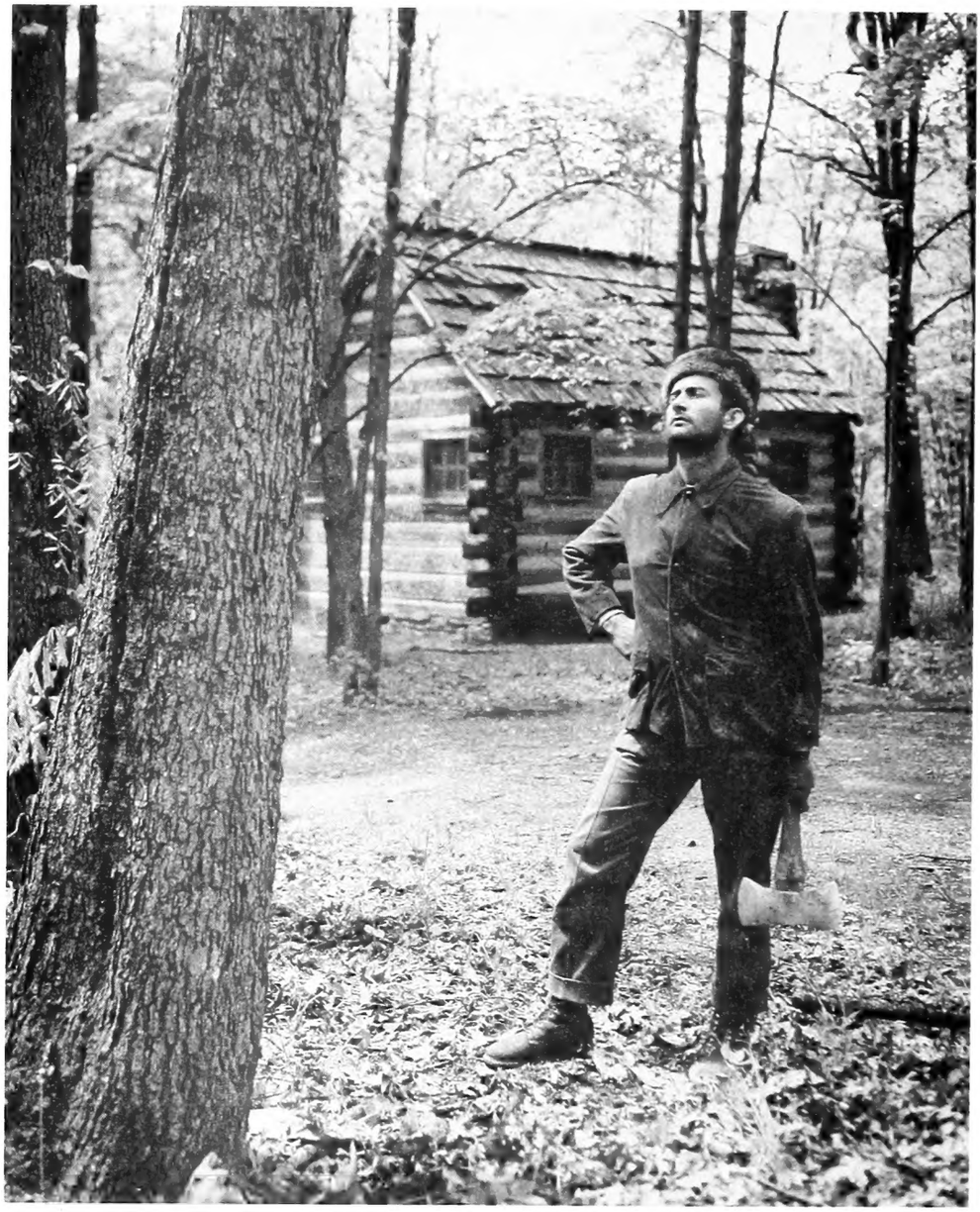
Indian troubles plagued the white man and inhibited settlement until after the Revolution when General "Mad Anthony" Wayne won the Battle of Fallen Timbers in the Maumee Valley near Toledo. After this defeat, the Indians accepted the Treaty of Green Ville in 1795, which opened up much of Ohio to white settlement.

At that time, Ohio's vast stretches of forest served as a barrier to agriculture. These forests were primarily old-growth hardwood stands that contained many gigantic trees. Some stands contained as much as 45,000 board feet per acre. Much of the cut timber was wasted but agriculture was emphasized at that time. Later a considerable amount of timber was used to produce charcoal used to fuel iron smelting furnaces and to manufacture various wood products.

Ohio pioneers were somewhat different from those that settled much of the East. They were often people of means who moved to Ohio to improve upon life rather than find opportunity for the first time (Wright 1957). Ohio was primarily an agricultural state, but after the War of 1812 the population grew rapidly and industry began to develop.

The Ohio River provided transportation to southern markets for farm surplus and various manufactured goods, including whiskey barrels, leather and woolen goods, paper, bricks, wagons, furniture, and farm equipment. Canal systems, the National Road (completed to Columbus in 1833), and toll roads constructed by turnpike companies also contributed much to Ohio's economic development. Markets also developed to the north and east and increased considerably with the coming of the railroad. By 1900, Ohio was a thriving manufacturing state, and except during the Depression years, this has continued.

Forests have been a part of Ohio's history. Pioneers often judged an area's desirability for agriculture by the type of forest present. Forests later provided the raw material for fuel and wood products. Today, Ohio's forests still supply many forest industries. They also supply many recreational opportunities, esthetic relief, and natural protection against erosion and water pollution. Forests continue to be important to the physical and emotional well-being of Ohio's residents. This report examines many aspects of Ohio's forest resources.



Pioneers often judged an area's desirability for agriculture by the type of forest present.

Geographic Regions

Ohio was divided into two distinct physiographic regions: The Hill Country covering the southeastern third of the state and the Glaciated Region covering the remainder of the state (Fig. 1).

Much of the Hill Country is part of the Allegheny Plateau and is characterized by hilly terrain, steep, winding valleys; and outcroppings of bedrock. It generally lacks agricultural richness except where rivers have deposited glacial silt enriching the lower valleys. The Hill Country comprises the 28 counties that form the South-Central, Southeastern, and East-Central units.

Figure 1.—Geographic regions and units of Ohio, 1979.

Ohio's Hill Country.

In the Glaciated Region, great ice sheets rounded off hills, filled valleys with fertile soil, and dammed streams creating lakes; many of which later became swamps. It is a region of flat and rolling plains, well suited for agriculture. The Glaciated Region includes the 60 counties that form the Northeastern, Southwestern, and Northwestern units. Much of the northwestern portion was once under Lake Erie and later constituted the Black Swamp area, an obstacle to pioneer settlement. Where drained, this land has become valuable for agriculture. Population density and the resulting pressure of development and urban sprawl are considerably greater in the Glaciated Region than in the Hill Country.

Each geographic region was divided into three geographic units (Fig. 1). These units were identical to those in the 1968 survey, except the 1968 Western Unit was divided into the Northwestern and Southwestern units. A few statistics for Ohio and each of the six units follow. Data for population are from the U.S. Department of Commerce, Bureau of the Census (1980).

Ohio

Counties: 88
Land area: 26,228,500 acres
Commercial forest: 6,917,100 acres (26%)
Per-acre volume of growing stock on commercial forest land: 924 cubic feet
Population: 10,797,419
Population density: 263.5 per square mile

South-Central Unit

Counties: 10
Land area: 3,307,500 acres
Commercial forest: 1,601,300 (48%)
Per-acre volume of growing stock on commercial forest land: 1,178 cubic feet
Population: 515,098
Population density: 99.7 per square mile

Flat rolling plains typify the Glaciated Region.

Southeastern Unit

Counties: 7
Land area: 2,075,500 acres
Commercial forest: 1,247,700 acres (60%)
Per-acre volume of growing stock on commercial forest land: 900 cubic feet
Population: 225,467
Population density: 69.5 per square mile

East-Central Unit

Counties: 11
Land area: 3,407,400 acres
Commercial forest: 1,657,700 acres (49%)
Per-acre volume of growing stock on commercial forest land: 719 cubic feet
Population: 521,993
Population density: 98.0 per square mile

Northeastern Unit

Counties: 17
Land area: 5,114,800 acres
Commercial forest: 1,240,400 acres (24%)
Per-acre volume of growing stock on commercial forest land: 856 cubic feet
Population: 4,370,971
Population density: 546.9 per square mile

Southwestern Unit

Counties: 16
Land area: 4,811,600 acres
Commercial forest: 470,200 acres (10%)
Per-acre volume of growing stock on commercial forest land: 1,030 cubic feet
Population: 3,489,105
Population density: 464.1 per square mile

Northwestern Unit

Counties: 27
Land area: 7,511,700 acres
Commercial forest: 699,800 acres (9%)
Per-acre volume of growing stock on commercial forest land: 924 cubic feet
Population: 1,674,785
Population density: 142.7 per square mile

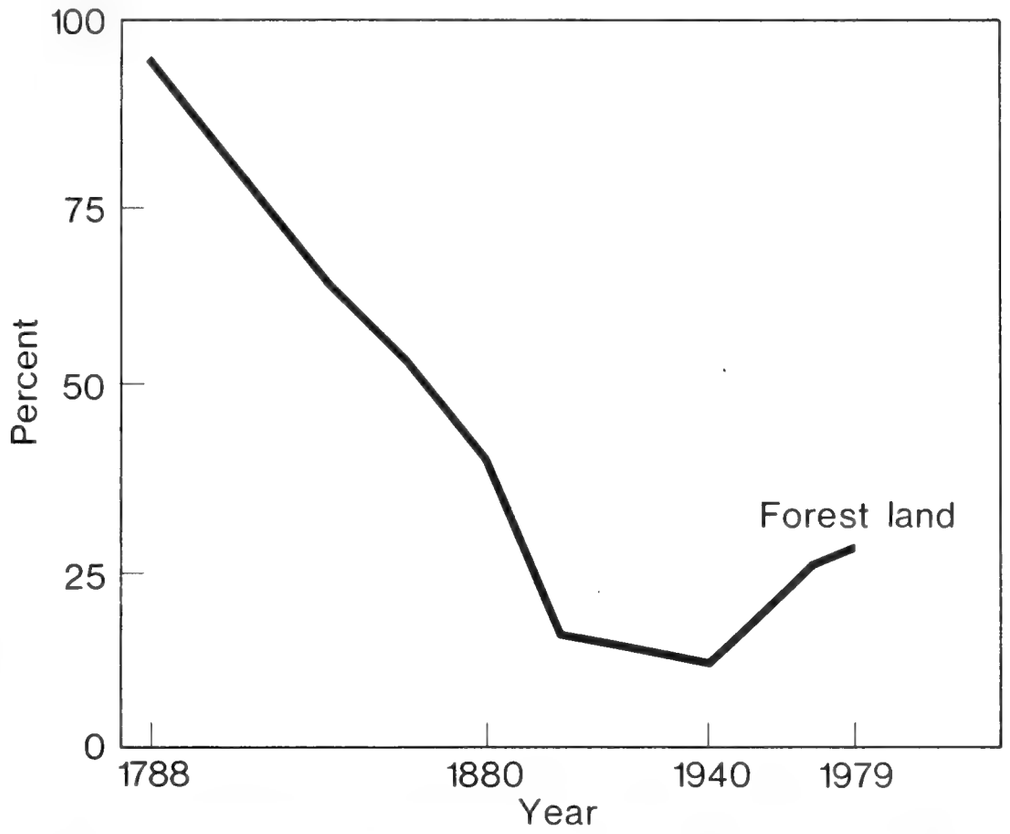
Forest Area

Ohio occupies 26,382,000 acres. This includes 158,000 acres of inland water (large lakes, rivers, and reservoirs) and 26.2 million acres of land. Just over 7.1 million acres, 27 percent, is forested. Most of this, 6.9 million acres, is considered commercial forest land (potentially productive forest land that is not administratively withdrawn from timber harvesting).

The remaining forest land (203,000 acres) falls into one of three categories: productive reserved, urban, or unproductive forest land. This land, though not a large portion of the total, is very important to many of Ohio's residents. Productive reserved forests, which include publicly owned parks and urban forests, provide recreational opportunities, important wildlife habitat, and esthetic relief. These benefits are also provided by trees and small forest stands (less than 1 acre) found on land classified as nonforest.

Before settlement, Ohio was almost entirely forested (Fig. 2). Land clearing, primarily for agriculture, steadily reduced the forest land base to about 15 percent as the 20th century began. This trend slowed significantly but was not reversed until 1940 when only 12 percent of Ohio remained forested. Since then, the forests have been recovering gradually and now occupy 27 percent of the state. This increase in forest land is mainly due to agricultural land reversion. Cropland has decreased approximately 7 percent since the 1968 survey but is still the most prevalent land use, accounting for 42 percent of Ohio's total area.

Figure 2.—Percentage of Ohio's land area in Forest for selected years.



Abandoned farmland that is reverting to forest is the source of most of Ohio's increased forest acreage.

Since our last survey in 1968, total forest land increased by 7.4 percent, almost 490,000 acres. During this same time, commercial forest land increased by 5.5 percent. This change varied across the state (Table 1).

Almost two-thirds of Ohio's commercial forest land is concentrated in the Hill Country, which is more than half forested. The Southeastern Unit clearly has the highest proportion of forest land—60 percent. Two counties, Lawrence and Vinton, are more than 70 percent forested, and six other counties are more than 60 percent forested. Forest land in the Hill Country increased slightly (2.5 percent) since the 1968 survey. This contrasts with the 33 percent increase that occurred between the 1952 and 1968 surveys.

Forest land increased more rapidly in the Glaciated Region (11.7 percent) than in the Hill Country since the 1968 survey. Although forest land is increasing, this is still a relatively open agricultural region. All but 12 of the 60 counties in the Glaciated Region are less than 20 percent forested (Fig. 3).

Forest Ownership

Almost all, 94 percent, of Ohio's commercial forest land is privately owned. Only 412,200 acres are publicly owned (Table 2). The Wayne National Forest includes 159,300 acres of commercial forest land; all of which is in the Hill Country. The state owns an additional 195,500 acres of commercial forest land, more than half of which is located in the South-Central Unit. Other federal and local government agencies hold the remaining 57,400 acres of other public forest land. Although public land is only 6 percent of the commercial forest land, it is quite important to many of Ohio's residents, particularly in providing opportunities for outdoor recreation.

The remaining 6.5 million acres of commercial forest land are held by a myriad of private owners, an estimated 332,600 in all. Ownership data are based on a questionnaire survey of private landowners conducted in conjunction with the forest survey of Ohio. More detailed ownership information may be found in "The Forest-Land Owners of Ohio" (Birch, in press).

Forest industries own 186,300 acres of forest land, 3 percent of the state total. An additional 529,400 acres (8 percent) is held by other corporations, much of which is held by coal companies and public utilities whose primary interest is coal extraction.

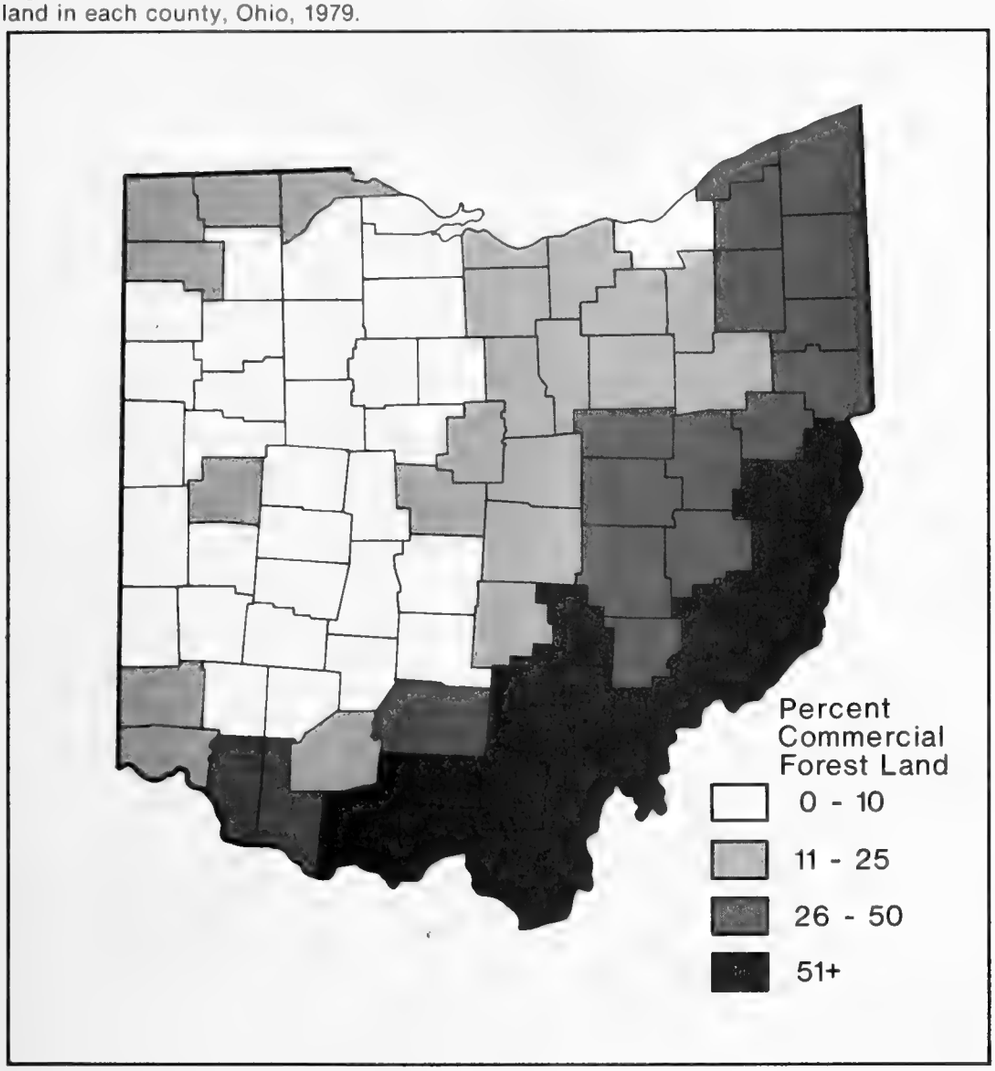
Farmers and other private owners hold the remaining 84 percent, 5.8 million acres, of Ohio's commercial forest land. This acreage is split about evenly between these two groups of owners. Most owners in each group are individuals, as opposed to partnerships, clubs, and other forms of ownerships. An estimated 305,200 individual owners collectively hold 5,159,400 acres of forest land in Ohio. These individuals have diverse occupations: 19 percent are professionals, white collar workers, or executives, 21 percent are retired, and 14 percent are farmers.

Table 1.—Area of commercial forest land by geographic unit and years, Ohio, 1952-79

Unit	1952	1968	1979	Percent change 1968-79
		(Thousand acres)		
		HILL COUNTRY		
South-Central	1,350[a]	1,560[b]	1,601	2.6
Southeastern	965	1,251	1,248	– .2
East-Central	995	1,586	1,658	4.5
Total	3,310	4,397	4,507	2.5
		GLACIATED REGION		
Northeastern	1,004[c]	1,130	1,240	9.7
Southwestern[d]	1,082	413	470	13.8
Northwestern[d]		615	700	13.8
Total	2,086	2,158	2,410	11.7
State total	5,396	6,555	6,917	5.5

[a] 1952 data for Hill Country is from Hutchinson 1954b.
[b] 1968 data for both regions is from Kingsley 1970.
[c] 1952 data for Glaciated Region is from Hutchinson 1954a.
[d] Only aggregate data are available for these two units for 1952.

Figure 3.—Distribution of forest land by percentage of commercial forest land in each county, Ohio, 1979.



Many of the individual forestland owners hold small amounts of forest land. Three-quarters of the owners hold less than 20 acres each and collectively own one-quarter of the individually owned forest land. The remaining 3.9 million acres are held by individuals who own at least 20 acres each and the average holding is approximately 50 acres. These larger holdings are more conducive to forest management. Most owners, however, hold their land for reasons other than timber production. Even if timber production is not their primary interest, owners with larger forest holdings are more likely to harvest timber. Thirteen percent of Ohio's individual owners plan to harvest timber from at least a portion of the million acres they own during the next 10 years.

Table 2.—Area of commercial forest land by forest-type group and ownership class, Ohio, 1979 (In thousands of acres)

Forest-type group	National Forest	Other public	Forest industry	Other corporate	Farmer	Misc. private	Total
White/red pine	9.4	17.4	19.3	23.7	45.7	50.4	165.9
Hard pine	10.0	—	6.8	18.9	61.0	43.2	139.9
Oak/pine	6.1	—	—	—	—	13.4	19.5
Oak/hickory	125.5	129.9	130.2	273.9	1,722.0	1,874.8	4,256.3
Elm/ash/red maple	1.7	13.2	—	110.3	309.8	316.7	751.7
Northern hardwoods	6.4	92.4	22.1	110.5	723.8	551.5	1,506.7
Aspen/birch	.2	—	—	—	26.6	50.3	77.1
Total	159.3	252.9	178.4	537.3	2,888.9	2,900.3	6,917.1

Stand Size

Area in both poletimber- and sawtimber-size stands increased significantly since the last survey (Fig. 4). Much of the reverting agricultural land, that was in the seedling-sapling stage in 1968 is now considered poletimber or in some cases sawtimber-size stands. It is possible for a 1968 seedling-sapling stand to move into the sawtimber category during the 11 years between surveys. For example, sapling stands may contain some poletimber or sawtimber trees, as in a reverting pasture or in a stand that has been severely high-graded or commercially clearcut. These scattered large trees plus trees maturing in the understory may put on enough volume to move this stand into the sawtimber category in just 11 years.

Similar stand-size changes occurred in both regions of Ohio (Fig. 5), though some differences exist. There are porportionately more seedling-sapling stands in the Hill Country, even though most of the cropland reversion since 1968 was in the Glaciated Region. These regional averages are influenced significantly by two units: the Hill Country's East-Central Unit, with the highest proportion of seedling-sapling stands, and the Glaciated Region's Northwestern Unit with the lowest proportion of seedling-sapling stands in the state. In the East-Central Unit, much strip-mined land has been planted with trees, creating stands currently in the seedling-sapling stage. In addition, some cropland that was abandoned due to stripping activities on neighboring land reverted to forest and is now seedling-sapling stands of pioneer species. In addition to having the lowest proportion of seedling-sapling stands, the Northwestern Unit also has the highest proportion of sawtimber stands in the state.

Figure 4.—Area of commercial forest land by stand size, Ohio, 1968 and 1979.

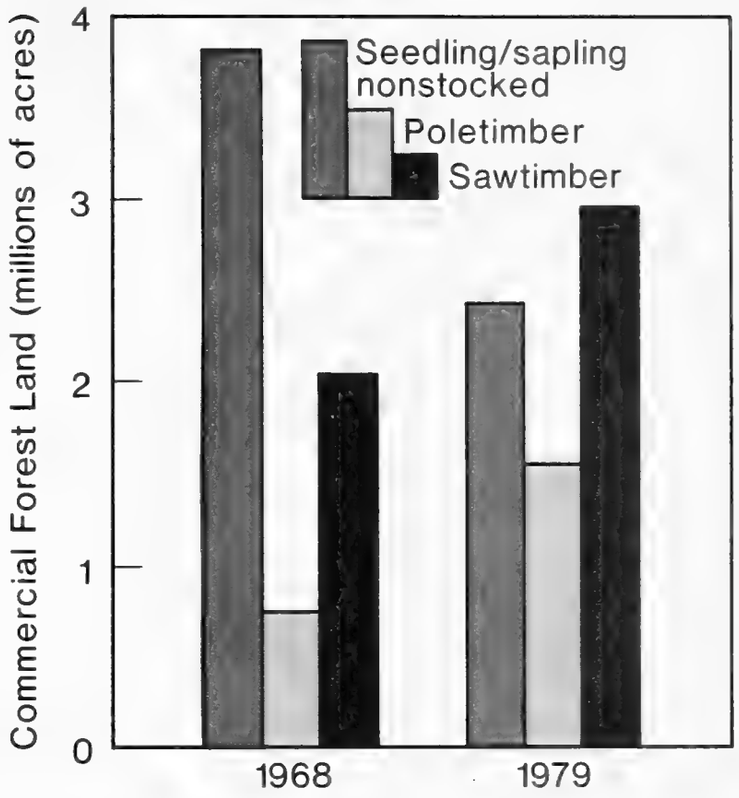


Figure 5.—Area of commercial forest land by stand size and geographic region, Ohio, 1968 and 1979.

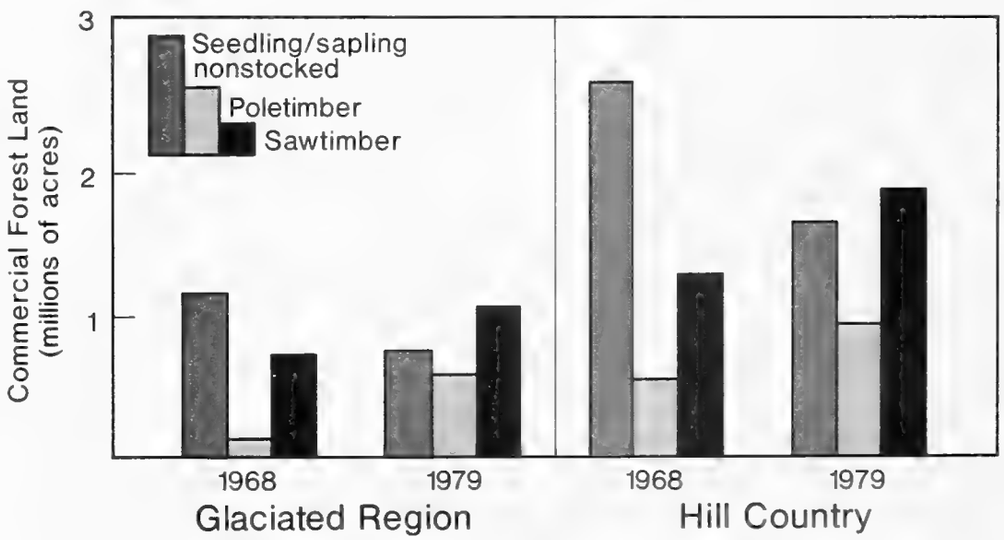


Table 3.—Area of commercial forest land by stand-size and ownership class, Ohio, 1979 (In thousands of acres)

Stand-size class	National Forest	Other public	Forest industry	Other corporate	Farmer	Misc. private	Total
Sawtimber stands	87.6	158.8	72.2	155.6	1,325.0	1,155.4	2,954.6
Poletimber stands	47.2	31.4	19.8	115.0	718.0	606.5	1,537.9
Sapling-seedling stands	21.2	52.5	65.0	266.7	780.2	1,022.9	2,208.5
Nonstocked areas	3.3	10.2	21.4	—	65.7	115.5	216.1
Total	159.3	252.9	178.4	537.3	2,888.9	2,900.3	6,917.1

Compared to other ownerships, public land, both national forest and state, has proportionately more area in sawtimber stands (Table 3). Much of this land has been held in public ownership for a relatively long time allowing stands to reach the sawtimber stage. Large size stands offer many opportunities for outdoor recreation, such as hiking and camping, and also provide habitat for many wildlife species.

The other corporate owner group, which includes coal companies and incorporated public utilities, had the highest proportion of seedling-sapling stands. Half of their holdings are in the seedling-sapling stage. Strip mining has certainly influenced stand development for these ownerships.

Forest Type

Ohio's commercial forest land has been categorized into 32 forest types, combined to form 7 major forest-type groups (Table 4). Three of these groups—oak/hickory, northern hardwoods, and elm/ash/red maple—account for 95 percent of the total forest area (Fig. 6). Softwood forest types, the oak/pine types, and aspen comprise the remaining 5 percent of Ohio's forest area.

Table 4.—Area of commercial forest land by forest type and forest-type group, Ohio, 1979 (In thousands of acres)

Forest type and forest-type group	Area
Red pine	41.0
White pine	124.9
Total white/red pine group	165.9
Shortleaf pine	15.6
Virginia pine	74.9
Eastern redcedar	36.7
Pitch pine	12.7
Total hard pine group	139.9
Shortleaf pine/oak	7.3
Other oak/pine	12.2
Total oak/pine group	19.5
Post, black, or bear oak	133.5
Chestnut oak	251.3
White oak	341.5
Northern red oak	116.2
Scarlet oak	16.2
White oak/red oak/hickory	1,076.0
Yellow-poplar	457.0
Sweetgum/yellow-poplar	25.4
Black locust	411.0
Black walnut	99.2

(Continued)

Table 4 (Cont.)

Forest type and forest-type group	Area
Sassafras/persimmon	287.2
Hawthorn/reverting field	348.7
Red maple/central hardwoods	284.7
Mixed central hardwoods	408.4
Total oak/hickory group	4,256.3
Black ash/American elm/red maple	607.1
River birch/sycamore	51.9
Cottonwood	27.9
Willow	49.5
Sugarberry/American elm/green ash	15.3
Total elm/ash/red maple group	751.7
Sugar maple/beech/yellow birch	613.2
Black cherry	280.9
Red maple/northern hardwoods	165.0
Mixed northern hardwoods	447.6
Total northern hardwoods group	1,506.7
Aspen	77.1
Total aspen/birch group	77.1
State total	6,917.1

Oak/hickory forests prevail throughout the midwest and mid-Atlantic regions. Ohio is no exception, with almost two-thirds of its commercial forest area in oak/hickory forests. The white oak/red oak/hickory type occupies more than a million acres and is clearly the most prevalent forest type in Ohio. It is found across the state on both glaciated and nonglaciated soils with a wide range of moisture conditions.

Significant differences exist between the distribution of forest types in the two regions of Ohio (Fig. 7). Oak/hickory forests are most common in both regions, however, they clearly dominate the Hill Country where they occupy almost three-quarters of the forested area. The yellow-poplar type, an important component of the oak/hickory group, is found almost exclusively in the Hill Country. This type is found on high-quality sites where soils tend to be deep, moist, and well drained. Undeveloped sites well suited to this forest type are rare in the highly agricultural Glaciated Region.

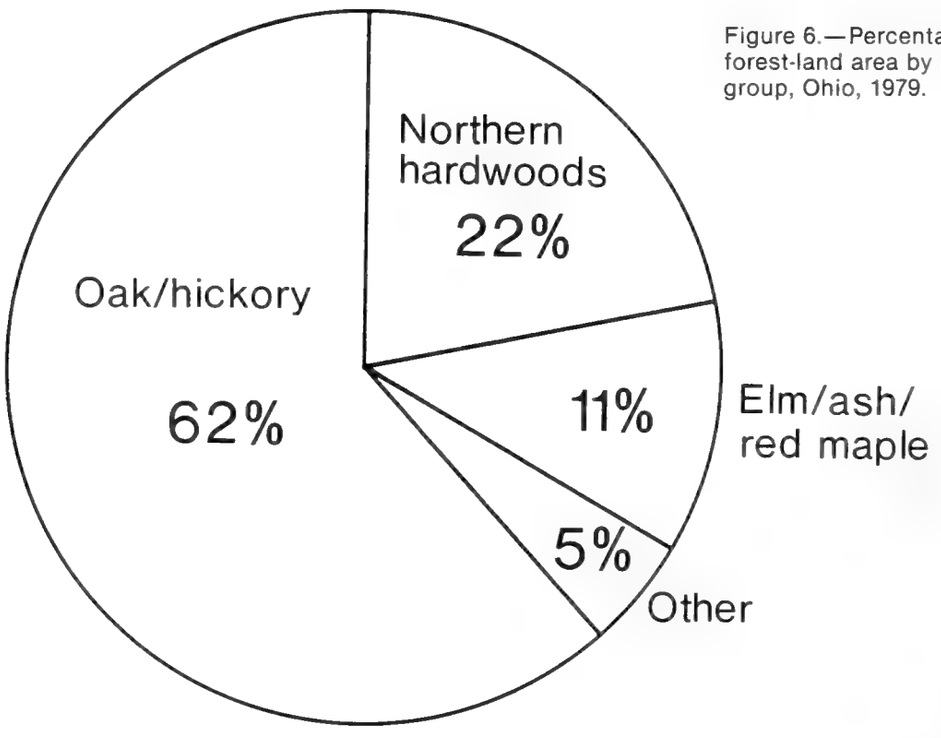
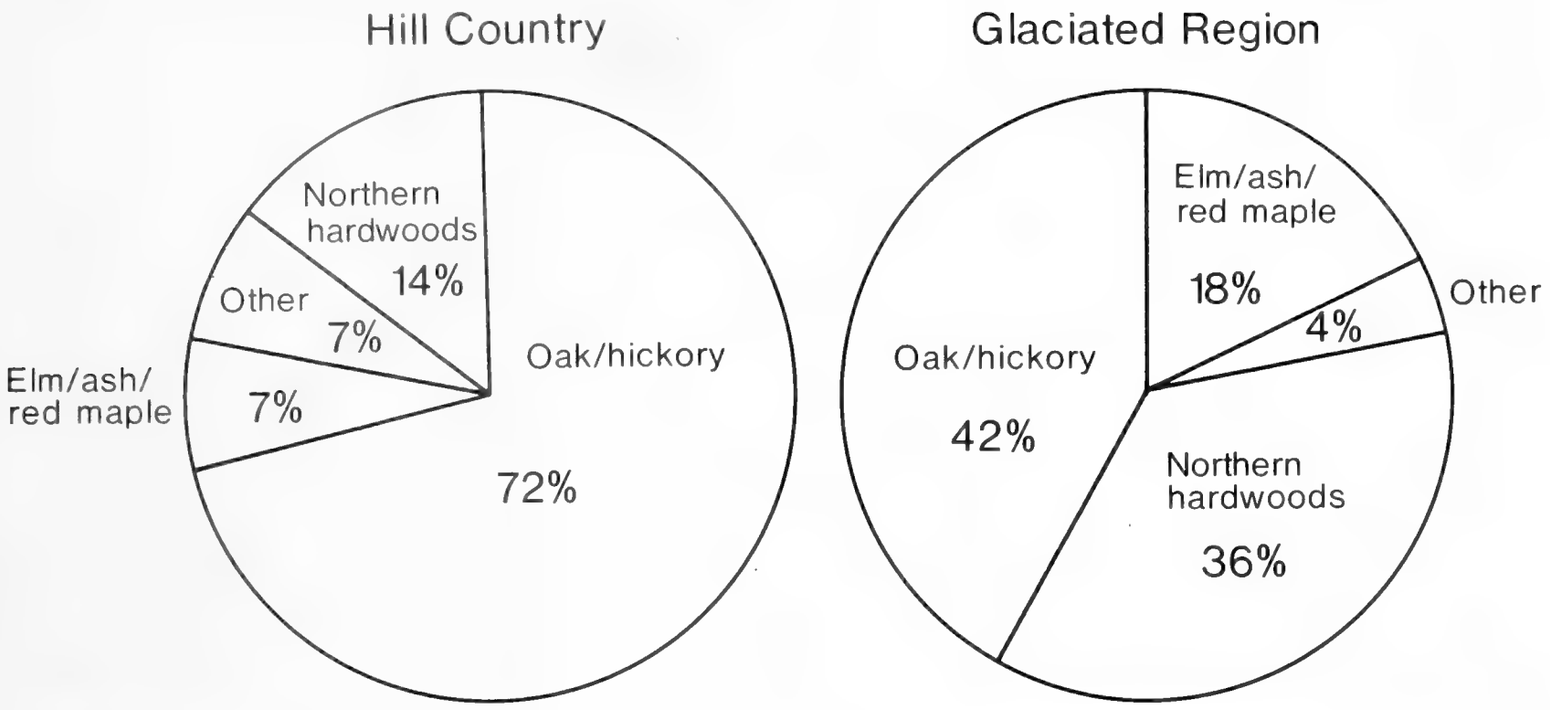


Figure 6.—Percentage of commercial forest-land area by major forest-type group, Ohio, 1979.

Figure 7.—Percentage of commercial forest-land area by major forest-type group and geographic region, Ohio, 1979.

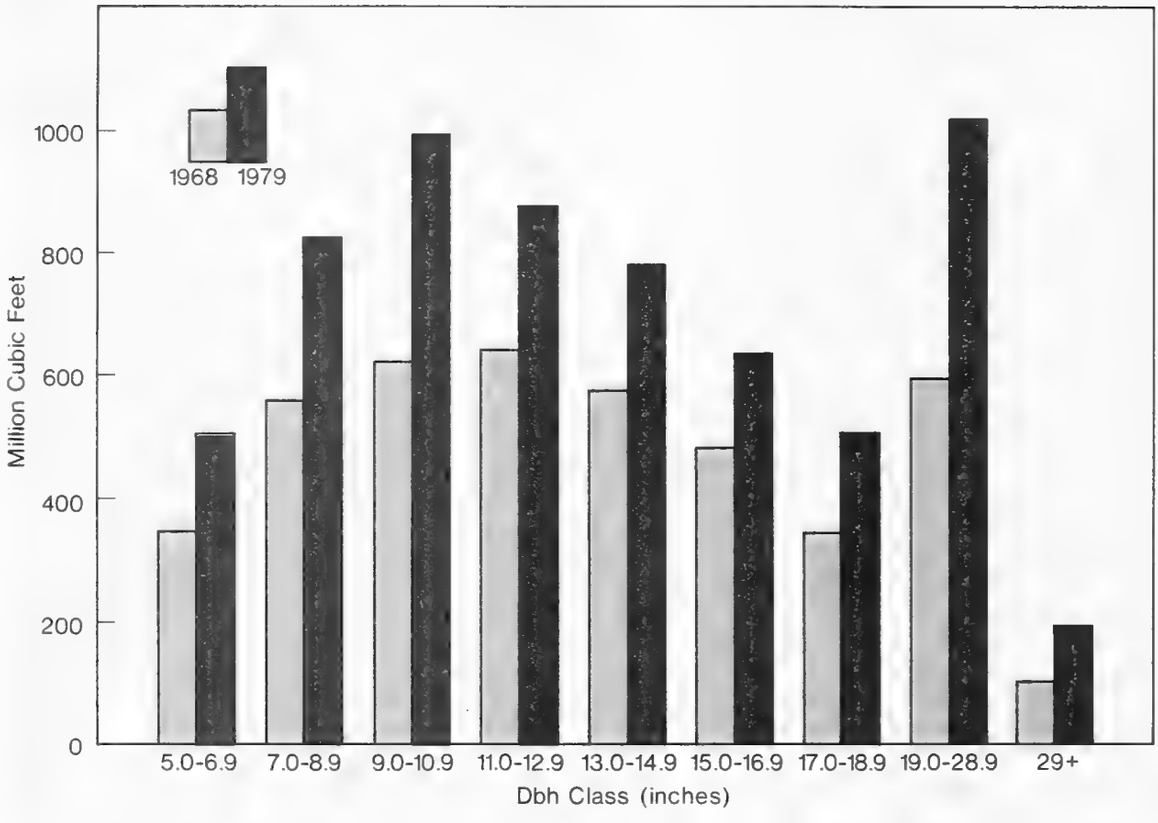


Black locust is frequently used for strip-mine reclamation.

Hawthorn/reverting field and sassafras/persimmon, two early succession forest types, together occupy 15 percent of the state's oak/hickory area. The hawthorn type occurs in both regions and has been greatly increased by human disturbance. It occurs on woodlot margins, old fence lines, old fields, and especially unmanaged pastures. The sassafras/persimmon type, almost exclusively confined to the Hill Country, occurs on upland old fields. Occurrence of these types is closely linked to the abandonment of marginal farmland in Ohio.

More than half the state's area in the black locust forest type, another component of the oak/hickory group, is concentrated in the East-Central Unit where strip mining has been quite active. It is often planted to control erosion and for strip mine reclamation because it provides quick cover and improves site quality (it's a legume), and its light crown encourages establishment of other species. It is also excellent for developing wildlife habitat on spoil banks.

Figure 8.—Distribution of growing-stock volume by diameter class, Ohio, 1968 and 1979.



Statewide, northern hardwoods cover a million and a half acres, almost a quarter of the commercial forest land. More than a third of the Glaciated Region is northern hardwoods compared to 14 percent found in the Hill Country. Compared to oaks, northern hardwoods tolerate cooler and moister conditions and therefore occur more frequently in the more northern Glaciated Region. The sugar maple/beech/yellow birch type is the most common northern hardwood type occupying over 600,000 acres.

The elm/ash/red maple type group is distributed similarly to the northern hardwoods with respect to the two geographic regions. Eighteen percent of the Glaciated Region is elm/ash/red maple compared to 7 percent in the Hill Country. Black ash/American elm/red maple is the principal type in this group and occupies just over 600,000 acres, statewide. This type is found on very moist sites—swamps, gullies, and depressions—and also occurs on glacially derived soils of varying textures where the drainage pattern causes a high water table (Eyre 1980). Conditions that favor this forest type tend to inhibit agricultural development. Much of the better drained land is devoted to farm use in the highly agricultural Glaciated Region.

Stand-size distribution among the major forest-type groups does not vary greatly. In general, the elm/ash/red maple, softwood, and aspen groups are in smaller size stands than the oak/hickory and northern hardwood groups. However, the stand-size variation among the individual forest types varies considerably. Information providing the breakdown of the acreage in the various forest-type groups by type of ownership is presented in Table 2.

Timber Volume

Dramatic Increase

Both growing-stock and sawtimber volumes increased tremendously (48 percent) since the 1968 survey. Growing-stock volume is now 6.4 billion cubic feet, and sawtimber volume is 20.4 billion board feet. Ohio's forests are maturing. Much land that was previously cutover or in agricultural use regenerated to forest and is now in the poletimber stage. Net growth also increased dramatically while timber removals dropped slightly, allowing volumes to build. Forest area supporting stands with more than 5,000 board feet per acre doubled since 1968.

This large volume increase is illustrated by the diameter class distribution of the growing-stock volumes in 1968 and 1979 (Fig. 8).

There was an across the board, volume increase and the overall shapes of the distributions remained similar between surveys. The bulge in the poletimber and small-sawtimber classes was maintained by continued ingrowth from younger stands. Over time, this bulge is expected to shift outward as Ohio's forests continue to mature. Similar bulges in volume have been observed in Pennsylvania and other states where significant cropland reversion or growth on cutover land occurred over a relatively short time.

Although the absolute volume change was greater in the Hill Country, which contains two-thirds of the state's growing-stock and sawtimber volumes, the Glaciated Region has shown a more rapid rate of increase (64 percent) since 1968. Net growth per acre was higher in the Glaciated Region for various reasons. Ingrowth has been a larger portion of gross growth in the Glaciated Region. Because ingrowth is picked up all at once (when the tree becomes 5 inches dbh), it contributes a great deal to percentage increases. Also, mortality and cull increment were a lower percentage of gross growth, and removals pressure has been less in the Glaciated Region, allowing volumes to build at a faster rate.

Generally, the intolerants or pioneer species such as aspen, black locust, black cherry, yellow-poplar, and white ash increased at the fastest rates. This is due to a number of reasons; one of which is their naturally fast growth rates. Many of Ohio's seedling-sapling stands originated on reverting farmland. These stands are now maturing and contributing sizable amounts of ingrowth, which translates into large percentage increases. Another reason for the rapid increase of these species is relatively low removals rates, particularly when compared to the oaks and hickories.

Although not increasing at a rate as fast as the intolerant species, oaks and hickories still dominate in terms of total volume. They have borne the brunt of the removals pressure, but still only half the net growth is being removed.

Quality Has Improved

Ohio's timber quality has improved. Sixteen percent of all trees more than 5 inches dbh are cull (trees that are too rough or rotten to be considered growing stock). This is an improvement since 1968 when 26 percent were classified cull. Three quarters of the cull trees were termed cull because their form was too rough. The remaining trees had too much rotten material to be considered growing stock.

The proportion of the total timber volume (in trees more than 5 inches dbh on commercial forest land) considered cull decreased from 14 percent in 1968 to 7 percent in 1979. This decrease in both number and volume of cull trees indicates a substantial improvement in the condition of Ohio's forests. Many factors influence changes such as these. The vigorous growth stage of the forest, the increased use of fuelwood and other products using lower quality timber, and good forest protection from fire and pests are some of the factors aiding in the improvement of Ohio's timber resource.

Sawlog quality has also improved. The percentage of hardwood sawtimber in grade 1 and 2 material has increased from 33 percent in 1968 to 37 percent in 1979. The volume of grade 1 and 2 material has increased by 2.6 billion board feet. Size is an important criteria in determining sawlog quality. To become Grade 1 material, hardwoods must attain a minimum diameter of approximately 15 inches. As the previously mentioned bulge in volume moves outward into the larger diameter classes, an additional improvement in quality is expected. Many well-formed, young trees will move into the better grades as their size increases. Also, many of the factors that reduced the proportion of rough and rotten trees will enhance sawlog quality as well.

Species

The top 10 species groups in Ohio in 1979 were:

Species	*Percent of total volume*
GROWING STOCK	
Select white oaks	12
Hickory	9
Other red oaks	9
Yellow poplar	8
White ash	7
Hard maple	7
Select red oaks	6
Soft maple	6
Chestnut and post oaks	5
Black cherry	4
SAWTIMBER	
Select white oaks	15
Other red oaks	11
Yellow-poplar	9
Hickory	8
Select red oaks	8
Hard maple	6
White ash	6
Chestnut and post oaks	6
Beech	4
Soft maple	4

Select white oaks. White oak, swamp white oak, bur oak and chinkapin oak are included in this group in Ohio. White oak is by far the most prevalent, accounting for 86 percent of the select white oak growing-stock volume. This commercially valuable group accounts for 12 percent of the growing-stock and 15 percent of the state's sawtimber volumes. Growing-stock volume has increased by 30 percent, and sawtimber volume by 38 per-

cent since the 1968 survey. White oak often becomes dominant in stands because it has the ability to thrive for long periods in the understory and respond quickly to release (Fowells 1965).

Percentage of growing-stock volume by species and diameter class in 1979 is given in Table 5. More than three-quarters of the select white oak volume is in sawtimber-size trees with more than half in trees above 15 inches dbh. White oak is a naturally long-lived tree capable of reaching 150 feet tall and 8 feet in diameter. Sawlog quality is fairly good with 43 percent of the volume in grade 1 or 2, an improvement since 1968. In addition, only 5 percent of the select white oak trees are considered cull.

White oak is found across the state and grows well on a wide range of soils and sites. It ranks first in the Hill Country and third in the Glaciated Region in terms of growing-stock volume. White oak is particularly concentrated in the South-Central Unit where almost 40 percent of its volume is found.

Hickory. Hickory ranked second in growing-stock and fourth in sawtimber volume. Hickory occurs frequently in both regions and is particularly abundant in the Northwestern Unit, where it accounts for 20 percent of the total growing-stock volume. Figure 9 shows growing-stock volume in Ohio by species, in 1968 and 1979.

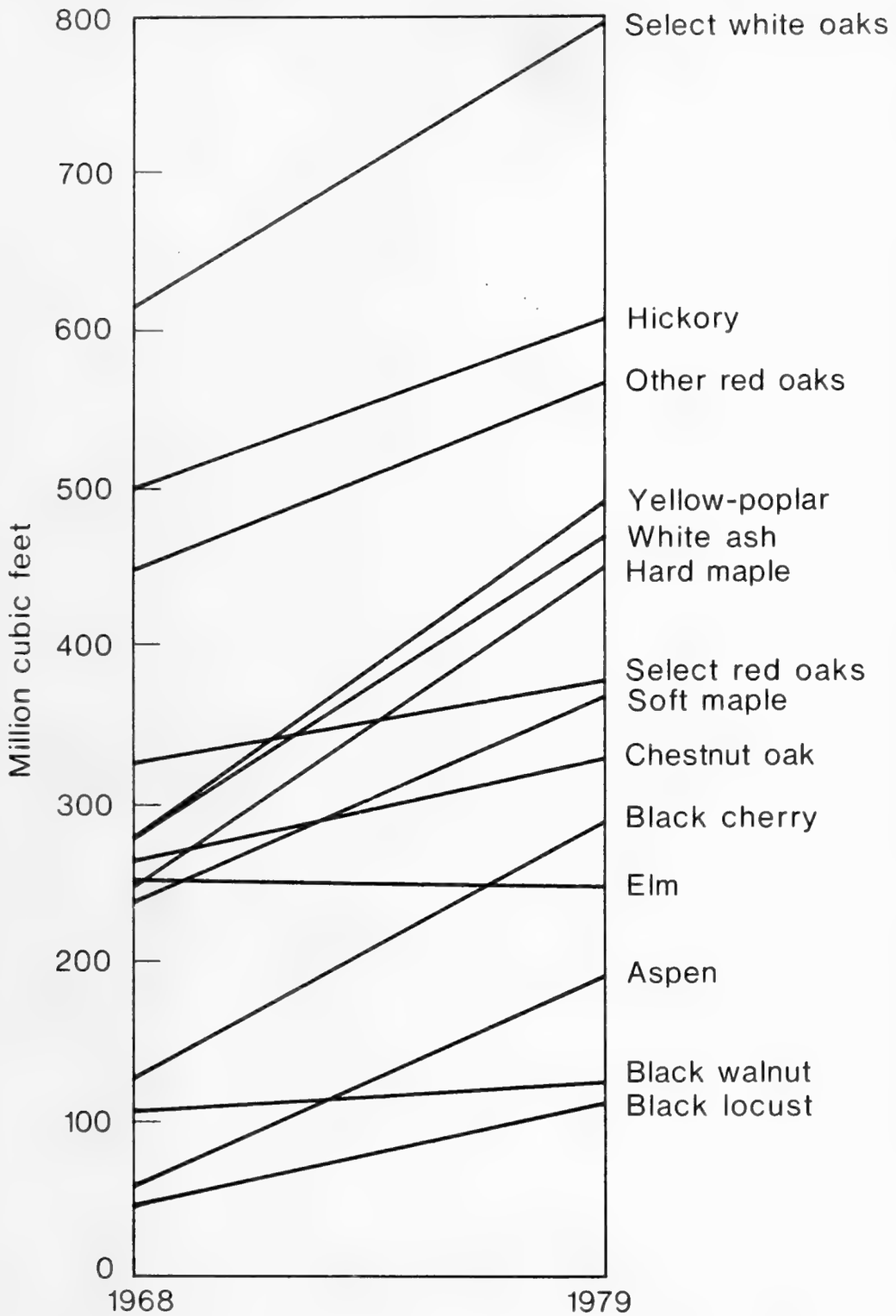
Sawlog quality has improved but still only 30 percent of the sawtimber volume is in grade 1 and 2 material. This is partially explained by its relatively small size when compared to the oaks. Only a quarter of its growing-stock volume is in trees more than 15 inches dbh. Quality should continue to improve as diameters increase. Only 6 percent of all trees are considered cull.

Table 5.—Percent of growing-stock volume by species and diameter class, 1979

Species	Diameter class (inches at breast height)										
	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29+	Total
White and red pine	17	31	23	22	4	3	—	—	—	—	100
Virginia pine	14	25	30	16	10	3	1	1	—	—	100
Other softwoods	19	13	23	18	16	7	1	2	1	—	100
Total softwoods	17	22	25	18	11	5	1	1	W	—	100
Soft maple	15	19	17	12	9	7	5	4	8	4	100
Hard maple	8	13	17	16	12	11	8	7	6	2	100
Hickory	8	17	19	16	14	10	7	4	5	W	100
Beech	4	8	12	15	8	8	6	10	22	7	100
White ash	9	14	17	13	14	10	10	4	7	2	100
Black walnut	5	18	21	14	16	13	5	6	2	—	100
Yellow-poplar	4	10	14	15	13	14	10	6	13	1	100
Sycamore	3	7	16	15	10	9	8	9	14	9	100
Aspen	14	22	17	17	8	5	2	1	6	8	100
Black cherry	8	17	23	16	14	9	3	5	4	1	100
Select white oaks	4	8	10	10	14	14	13	9	14	4	100
Select red oaks	4	7	10	9	12	10	9	9	19	11	100
Chestnut oak (and post)	3	8	13	19	16	15	8	6	9	3	100
Other red oaks	3	7	10	11	13	11	12	9	19	5	100
Black locust	14	20	27	14	11	7	4	0	2	1	100
Elm	21	22	20	12	8	4	5	3	5	—	100
Other hardwoods	14	14	17	13	11	8	6	5	9	3	100
Total hardwoods	8	13	15	14	12	10	8	6	11	3	100
Total all species	8	13	16	14	12	10	8	6	10	3	100

W—Less than 0.5 percent.

Figure 9.—Growing-stock volume in Ohio by species, 1968 and 1979.



Other red oaks. Scarlet oak, shingle oak, pin oak, and black oak are included in this category in Ohio. Black oak, by far the most prevalent, is intermediate in shade tolerance and does very well on dry sites. However, pin oak is a wet-site intolerant species.

Other red oaks rank third in growing-stock and second in sawtimber volume, statewide. They have exhibited a 25 percent increase in growing-stock volume and a 39 percent increase in sawtimber volume while sustaining a relatively high removals rate. Still, 80 percent of its volume is in sawtimber-size trees with half being in trees above 15 inches dbh. Sawlog quality is somewhat poorer for other red oaks than for other oaks despite its high percentage of large trees. But only 4 percent of all other red oaks more than 5 inches dbh are cull.

Yellow-poplar. One of the fast-growing intolerants, yellow-poplar increased its volume significantly since the previous survey. Both growing-stock and sawtimber volume increased by more than 75 percent because yellow-poplar is a naturally fast growing species and experienced relatively low removals pressure and a low mortality rate.

Yellow-poplar is often a pioneer on abandoned farmland or cutover land. It is somewhat demanding in its soil and moisture requirements and is usually found on moderately moist, well-drained, loose textured soils. It rarely grows well in very dry or very wet situations. Almost all of Ohio's yellow-poplar volume is found in the Hill Country. Sites ideally suited for yellow-poplar and not devoted to agriculture are rare in the Glaciated Region.

Yellow-poplar, often a pioneer species on abandoned farmland, has significantly increased in volume.

Very few (3 percent) of the yellow-poplar trees above 5 inches dbh are considered cull. Yellow-poplar is unusually free from disease problems. More than two-thirds of the growing-stock volume is in sawtimber-size trees, and sawlog quality is slightly better than the average for all hardwoods.

White ash. White ash, another fast growing pioneer species that often seeds in on the more fertile abandoned fields, is also gaining volume rapidly. Low removals pressure helped foster a 66 percent increase in growing-stock volume. Unlike yellow-poplar, white ash is concentrated in the Glaciated Region. Much of the white ash volume (43 percent) is in poletimber size trees, which helps to explain its low removals rate. White ash is shade tolerant when young and decreases in tolerance as it gets older. It becomes less common in the larger size classes.

Sawlog quality is fairly good despite its relatively small size; only a third of its volume is in trees above 15 inches dbh. Its single stemmed nature and quick self-pruning characteristics help to improve quality. Twelve percent of the white ash trees above 5 inches dbh were considered cull.

Ash's straight grain, strength, good bending properties, capacity to wear smooth, and high shock resistance make it desirable for many products such as: tool handles, furniture, flooring, millwork and, of course, baseball bats.

Hard maple. Hard maple, almost entirely sugar maple, is a tolerant species that is increasing at a rapid rate. Growing-stock volume increased by 81 percent since 1968. It ranks sixth in both growing-stock and sawtimber volumes. Good seed production and prolific sprouting assure reproduction and its continued existence throughout its range. Sugar maple has also experienced light removals pressure and a low mortality rate, allowing volumes to build.

Sugar maple is a long-lived species, capable of reaching large sizes. Currently about one-third of its volume is in trees more than 15 inches in diameter. If removals pressure remains light, sawtimber volumes will increase significantly. Sawlog quality is below that of the oaks but should improve as diameters increase and approach the oak diameter distribution. Only 8 percent of the hard maples above 5 inches dbh are considered cull, which is split about evenly between rough and rotten trees. Hard maples are found across the state but are most prevelent in the South-Central and Northeastern units.

Select red oaks. Northern red oak was the only select red oak encountered in our survey of Ohio. It is distributed across the state, ranking seventh in growing-stock and fifth in sawtimber volume. Growing-stock volume increased by a modest 16 percent since the previous survey. Removals pressure has been relatively high for this species.

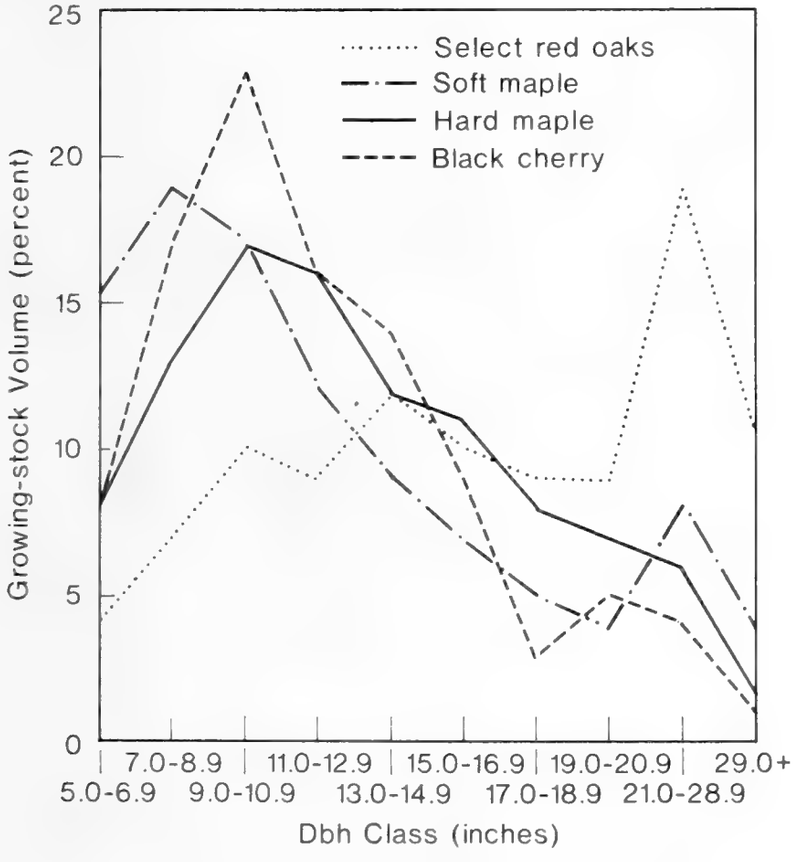
Almost 80 percent of the volume is in sawtimber trees; most volume is in trees above 15 inches dbh. Sawlog quality is quite good with more than half the sawtimber volume in grade 1 or 2 material. Northern red oak develops a tall

straight bole and prunes itself well under forest conditions. This and the high percentage of large trees account for the good sawlog quality. Cull trees comprise only 5 percent of the total number of live northern red oaks, and mortality does not seem to be a problem.

Soft maple. This category is primarily red maple but does include some silver maple. Red maple is found on a wide range of sites and is a component of many forest types. It is found across the state, but three-quarters of its volume is found in three units: the South-Central, East-Central and Northeastern units. Growing-stock volume increased quite rapidly, 55 percent, but sawtimber volume increased by only 18 percent since 1968. Both removals and mortality have been relatively low.

Ohio's red maple diameter distribution is skewed toward the lower diameter classes (Fig. 10). Half of the growing-stock volume is in poletimber and about a quarter is in trees above 15 inches dbh. Small size and the fact that red maple is not a preferred timber species, help explain the low removals rate. Small size also contributes to red maple's poor sawlog quality, only 24 percent is grade 1 or 2. Red maple is relatively short lived, when compared to sugar maple, and is quite susceptible to insect and disease attacks as well as physical damage. So, improvement in quality is not as promising as it is with sugar maple. So far, mortality has not taken a greater toll because most of the red maple is still fairly young.

Figure 10.—Diameter-class distribution for selected species, Ohio, 1979.



Chestnut oak. This group includes a small amount of post oak. Chestnut oak is typically an upland, dry-site oak and is almost exclusively found in the Hill Region. It is particularly concentrated in the South-Central Unit, which accounts for 63 percent of its volume. The rate of growing-stock volume increase has been similar to the other oak groups, and sawtimber increase has been slightly higher. Unlike the other oak groups, chestnut oak volume is concentrated in the large poletimber and small sawtimber classes. The other oaks are generally larger. Chestnut oak is naturally a medium-size species that normally reaches 60 to 80 feet in height and 20 to 30 inches in diameter on good sites.

Sawlog quality is fairly good with 42 percent in grade 1 and 2 material. Chestnut oak is intermediate in tolerance. It self prunes relatively well in forest conditions and will often show excellent form on good sites. Only 7 percent of the chestnut oak trees are cull.

Black cherry. Growing-stock volumes more than doubled since the 1968 survey. Black cherry, often a pioneer species, has a fast natural growth rate. Its diameter distribution is currently skewed toward the smaller classes (Fig. 10) with almost half of the growing-stock volume in poletimber-size trees. Sawlog quality is poor with only 24 percent of

the sawtimber in grade 1 or 2 material. This is partially due to the abundance of small-size trees. One out of five black cherry trees is considered cull.

Three-quarters of Ohio's black cherry volume is found in the Northeastern and East-Central units linking it with Pennsylvania's concentration of black cherry.

Elm. Elm was the only major species group to decline in volume since the previous survey. Growing-stock volume declined very slightly and sawtimber volume declined by almost 40 percent. Dutch Elm Disease, which attacks large elms, was responsible for this decline. Most of the current elm volume is in poletimber-size trees.

Almost a third of the remaining elm sawtimber is in grade 1 or 2 material. Elm is found across the state but is more frequent in the East-Central Unit, which contains about a third of the total growing-stock volume.

Beech. American beech increased moderately in volume—43 percent for growing stock and 22 percent for sawtimber. Sawtimber removals have been quite high for beech, which helps explain its low sawtimber increase.

Beech is a long-lived, shade tolerant species. Three-quarters of the growing-stock volume is in sawtimber-size trees with more than half in trees larger than 15 inches dbh. Despite beech's large size, sawlog quality is poor with only 18 percent in grade 1 or 2 material. Open-grown trees develop short, thick trunks, and epicormic branching is induced by stand cuttings such as hygrading operations, which in the past have left beech in favor of the more desirable timber species. Beech's thin bark makes it highly vulnerable to injury that often leads to rot. These factors will reduce sawlog quality. Beech is found across the state but occurs more frequently in the Glaciated Region.

Natural reproduction of aspen.

Aspen. Both bigtooth and quaking aspen occur, but bigtooth aspen is much more common in Ohio. Aspens are least common in the South-Central Unit and most common in the East-Central Unit. Some aspen has been planted for strip-mine reclamation, but most has come in naturally. It is a pioneer species that may become established quickly on abandoned farmland.

Aspen volume has shown a spectacular increase since 1968. Growing-stock volume has more than tripled, and sawtimber volume has quadrupled. In absolute terms, this increase does not impact the Ohio timber resource because aspen still represents only 3 percent of the total volume. However, it does illustrate change in Ohio—reversion of farmland with the resultant increase in pioneer species.

An increase in aspen is generally good for wildlife. Deer commonly browse on aspen sprouts and leaves. Grouse will also use aspen buds as a major winter food.

Aspen is a fast growing, medium size tree. More than half of its growing-stock volume is currently in poletimber-size trees. Ohio's aspen are generally in good condition with only 2 percent of the trees more than 5 inches dbh considered cull. It is a short-lived species and unless used, may deteriorate rapidly.

Aspen is a soft, lightweight wood with relatively low strength. It does have good nail holding ability and seldom splits when nailed. It is mainly used for pulp products and does make an excellent container wood.

A fine black walnut stands tall.

Black walnut. This highly valued species increased modestly in both growing-stock and sawtimber volumes. These increases occurred primarily in the Glaciated Region. Pure stands of black walnut are rare as this species typically occurs as scattered trees or in small groups within the forest.

Only a quarter of its volume is in trees more than 15 inches in diameter. Black walnut is a fairly long-lived species that can reach large sizes. However, large black walnuts are highly valued for veneer production, and many are cut for this use. Sawlog quality is below that of the oaks which is not surprising since its size is generally smaller than that of the oaks.

Sycamore. Sycamore is a fast-growing, basically wet-site tree, most commonly found on flat land with abundant water. It is sometimes a pioneer on upland old fields but does not grow best on these sites. Sycamore occurs across the state but is more common in the Glaciated Region where it is an important component of the elm/ash/red maple group.

It is a relatively long lived, intermediate to intolerant species capable of reaching very large diameters. Its volume is concentrated in the larger diameter classes in Ohio, similar to that of the oaks. Sycamore's volume increase has roughly paralleled that of the state's total volume.

Black locust. Although still a small portion of the total, black locust doubled its growing-stock volume since 1968. Black locust is a very intolerant species but can adapt to a wide range of conditions when competition is limited. It is a legume and a desirable, frequently used species for strip-mine reclamation. Symbiotic, nitrogen-fixing bacteria, associated with root nodules, increase the nitrogen content of the soil, and its litter decomposes rapidly, recycling nutrients. Black locust volume is concentrated in the East-Central Unit where strip mining has been quite active and much black locust has been planted. Black locust will also encroach on abandoned farmlands by root suckers at rates of up to 10 feet per year.

Most of black locust's growing-stock volume is in poletimber-size trees. Not surprising, sawlog quality is basically poor. About a third of the black locust trees more than 5 inches dbh are cull due mostly to rot. This species is often attacked by the locust borer (*Megacyllene robiniae)*, which weakens the tree and makes it unfit for most commercial uses. Black locust is often used for fencing because of its natural durability and nail holding ability. It is a very dense, strong wood.

Softwoods. Although still a small portion of the total, Ohio's softwood volume more than doubled since 1968. White and red pine are concentrated in the East-Central Unit, which contains half of the states volume of these species. Much of the remaining volume is found in the two northern units. Almost all of the white and red pine volume occurs in plantations, which are currently in the poletimber and small sawtimber stage.

Virginia pine is concentrated in the South-Central and Southeastern units which form the northern boundary of this species' natural range in Ohio. Unlike white and red pine, Virginia pine is primarily of natural origin in Ohio.

Geographic Units

South-Central Unit. This unit has the highest per-acre and total timber volume. The South Central Unit, primarily oak/hickory forests, has more oak, hickory, yellow-poplar, and hard maple than that in any other unit. Stocking levels are quite good with half the commercial forest area fully stocked with

growing-stock trees. Volumes per acre of both growing stock and sawtimber are high for all stand size classes. Sawtimber stands average 6,500 board feet per acre, and scattered sawtimber trees on seedling/sapling stands average 800 board feet per acre. Cull is generally low, only 5 percent of the total timber volume, and quality is high with 42 percent of the sawtimber volume in grade 1 and 2 material.

Southeastern Unit. The Southeastern Unit ranks third in commercial forest area and growing-stock volume and a distant second in sawtimber volume. Per-acre volumes approximate the state average. Select white oak has the most volume and is followed by yellow-poplar. Hickory and the other oaks are also quite common. Just over 80 percent of the unit's growing-stock volume is found in the oak/hickory type group.

East-Central Unit. This unit ranks second in growing-stock and third in sawtimber volumes. Strip-mine activities have had more impact on this unit than on any other area in Ohio. It has the largest acreage of commercial forest land but the lowest volume per acre. Its forests are generally younger than those of other Hill Country units; the proportion of seedling/sapling stands is highest in this unit. This is basically due to strip mining in this unit and to the earlier abandonment of cropland in the more rugged southern Hill Country units.

The East-Central Unit contains half the state's black locust volume. This species is excellent for strip-mine reclamation and was frequently used for that purpose in this unit. Other pioneer species—yellow-poplar, red maple, black cherry, and aspen—are commonly found here. Strip mining activity sometimes causes abandonment of neighboring cropland, allowing the pioneer species to become established. Much of Ohio's white and red pine volume is also found here, primarily in plantations now in the poletimber stage of development.

Northeastern Unit. Although somewhat below the Hill Country units in commercial forest area and total timber volume, the Northeastern Unit clearly leads the Glaciated Region in both categories. It does, however, have lower per-acre volumes than those in the other two glaciated units. Stocking levels are relatively low with only a third of the area fully stocked with growing-stock trees. Much of this unit's volume is presently in poletimber trees. Per-acre volumes will increase as these trees mature. Sawtimber quality is not particularly good but should improve with the increase in tree size.

Compared to other units, the Northeastern Unit has significantly more area and volume in northern hardwood stands. Hard maple, white ash, and black cherry are the growing-stock volume leaders. This unit also contains a large amount of Ohio's red maple and beech volumes.

Southwestern Unit. This unit has the smallest commercial forest area and the lowest timber volume. Per-acre volumes are quite high though; only the South-Central Unit has more volume per acre of forest land. Almost half of the forest is in sawtimber stands averaging 6,300 board feet per acre. Seventy percent of the growing-stock volume is in sawtimber-size trees with much in trees greater than 15 inches dbh. This results in high-quality sawtimber; just over 40 percent of the sawtimber volume is in grade 1 or 2 material. White ash and select white oak are the volume leaders and together account for a third of the unit's sawtimber volume.

Northwestern Unit. More than half of the forest stands in this unit are in the sawtimber stage. Trees are generally large; 64 percent of the unit's growing-stock volume is in sawtimber-size trees. Per-acre volumes, however, are not high. Poletimber and seedling/sapling stands in this unit have relatively low volumes when compared to those in other units.

Hickory leads in both growing-stock and sawtimber volumes. White ash and select white oak are also important species in this unit.

Biomass

The main focal points of our timber inventory are growing-stock and sawtimber volumes on commercial forest land, but these volumes do not include Ohio's total timber volume. Growing-stock volume includes only the net volume in trees 5 inches dbh and larger, from a 1-foot stump to a minimum 4-inch top diameter outside bark or to the point where the central stem breaks into limbs. It does not include volume in cull trees or noncommercial species. Trees occurring on noncommercial or nonforest land are excluded entirely. These excluded volumes may be important to some, but were not within the scope of this survey.

Advances in technology for whole-tree chip harvesting and manufacturing products from chips have enabled operators to use smaller trees, tops, branches, and other nongrowing stock sources to meet wood requirements (see Timber Products). These sources are increasingly sought after for fuelwood to relieve high energy costs for both domestic and industrial use. This has stimulated a need for biomass information. Tables 6 and 7 supply data on the total green weight of aboveground biomass on commercial forest land in Ohio. These data include noncommercial species that are combined with the rough and rotten commercial species.

Just over half (56 percent) of the total biomass is in the merchantable stem portion of growing-stock trees more than 5 inches dbh. The remainder is in tops, branches,

Whole-tree chip harvesting has enabled operators to use smaller trees, tops, branches, and other nongrowing stock sources to meet wood requirements.

small trees, noncommercial species, and the merchantable stem portion of rough or rotten trees. Tops and branches comprise 21 percent of the total biomass. They comprise 24 and 27 percent, respectively, of the biomass found in growing-stock and cull trees. Compared to rough or rotten trees, growing-stock trees, are typically better formed and have proportionately less biomass in tops and branches. However, large trees, which are more likely to be harvested, have proportionately more total biomass in tops and branches. This proportion is 30 percent of the biomass in growing-stock trees 21 inches dbh or more. Tops and branches are a significant source of wood fiber that is available at the logging site.

The bole portion of rough and rotten trees comprises an additional 7 percent of the biomass on commercial forest land in Ohio. Removal and use of this material would improve the condition of the forest by providing more space for establishment and growth of desirable trees.

Table 6.—Total green weight of aboveground biomass on commercial forest land by class of timber and species group, Ohio, 1979

Class of timber	Softwoods	Hardwoods	Total
		(Million green tons)	
Growing stock:			
Merchantable stem	8.1	309.8	317.9
Tops and branches	4.1	95.3	99.4
Total growing stock	12.2	405.1	417.3
Rough and rotten:			
Merchantable stem	0.5	41.1	41.6
Tops and branches	.2	14.9	15.1
Total rough and rotten	0.7	56.0	56.7
Small trees (under 5″ dbh)	2.3	86.7	89.0
Total biomass	15.2	547.8	563.0

Table 7.—Total green weight of aboveground biomass on commercial forest land by class of timber and diameter class, Ohio, 1979

Diameter class (inches)	Growing stock		Rough and rotten		Total	
	Merchantable stem	Tops and branches	Merchantable stem	Tops and branches	Merchantable stem	Tops and branches
	(Million green tons)					
1.0 - 4.9	0	64.1	0	24.9	0	89.0
5.0 - 6.9	28.2	8.8	7.5	2.1	35.7	10.9
7.0 - 8.9	39.1	12.1	6.1	1.8	45.2	13.9
9.0 - 10.9	46.8	13.1	4.9	1.5	51.7	14.6
11.0 - 12.9	41.6	11.3	5.1	1.6	46.7	12.9
13.0 - 14.9	38.1	10.5	3.3	1.0	41.4	11.5
15.0 - 16.9	32.0	9.2	2.5	.9	34.5	10.1
17.0 - 18.9	25.9	8.3	1.8	.7	27.7	9.0
19.0 - 20.9	20.0	6.7	1.3	.5	21.3	7.2
21.0 - 28.9	35.0	13.4	6.6	2.2	41.6	15.6
>28.9	11.2	6.0	2.5	2.8	13.7	8.8
Total	317.9	163.5	41.6	40.0	359.5	203.5

An additional 16 percent (89 million green tons) of the biomass is in trees less than 5 inches dbh. This potential biomass is seldom used due to high extraction costs per unit of volume and the desirability of protecting young stands. However, small trees may be a desirable source of biomass from land-clearing operations if extraction costs are not prohibitive.

The feasibility of utilizing these different sources of biomass varies. As technology improves and energy costs soar, increased use of non-growing stock sources is expected.

Growth and Removals

Average Annual Growth and Removals

The large increase in timber volume that occurred in Ohio since the last survey can be broken down into various components (Table 8). The average annual increase in growing-stock volume was 188 million cubic feet for the 11-year period between surveys. Average annual net growth was 278.6 million cubic feet, and average annual removals were 90.6 million cubic feet. Only one-third of net growth was removed during this period. Removals pressure, though still a relatively low portion of net growth, was higher in the Hill Region.

Net growth can be broken down further: accretion (growth on the initial inventory), ingrowth (trees that became 5 inches dbh during the period), mortality, and cull increment (the volume of growing stock that became rough or rotten). Accretion plus ingrowth equals gross growth.

Table 8.—Components of average annual net change of growing-stock and sawtimber volumes, Ohio, 1967-78

Component	Growing stock	Sawtimber
	(Million cubic feet)	(Million board feet)
Accretion	259.9	560.3
Ingrowth	85.2	768.7
Gross growth	345.1	1,329.0
Cull increment	– 18.6	– 86.8
Mortality	– 47.9	– 232.7
Net growth	278.6	1,009.5
Removals	– 90.6	– 409.5
Net change	188.0	600.0

Gross growth averaged 345 million cubic feet per year, a considerable increase over gross growth between the 1952 and 1968 surveys. Three-quarters of the gross growth was accretion. With many stands moving from the seedling/sapling stage into the poletimber and sawtimber categories, one might expect ingrowth to be a larger component of gross growth than it has been in Ohio. Ingrowth is a small component of gross growth because of the high volumes of scattered poletimber and sawtimber trees found in many seedling/sapling stands. The growth on these larger trees in stands previously classified as seedling/sapling stands is accretion. The relationship between accretion and ingrowth is also illustrated by the large volume increases found across the diameter classes (fig. 8). This relationship is similar for both geographic regions, though the Glaciated Region did show a slightly higher ingrowth proportion (Table 9).

Table 9. Components of average annual net change of growing-stock volume by geographic region, Ohio, 1967–78

Component	Hill Region	Glaciated Region
	(Million cubic feet)	
Accretion	165.6	94.3
Ingrowth	49.2	36.0
Gross growth	214.8	130.3
Cull increment	– 12.5	– 6.1
Mortality	– 31.8	– 16.1
Net growth	170.5	108.1
Removals	– 60.1	– 30.5
Net change	110.4	77.6

Gross growth was reduced about 19 percent by cull increment and mortality over the past 11 years. This percentage may seem high, but Ohio ranks quite favorably when reductions due to cull and mortality in other states in the Northeast are compared. This reduction is also a lower percentage of gross growth than it was between the first and second Ohio surveys. Mortality was about three-quarters of the reduction for both regions.

The average annual increase in sawtimber volume was 600 million board feet. Components of this change were net growth of 1,009.5 million board feet and average annual removals of 409.5 million board feet. Approximately 40 percent of net sawtimber growth was removed over the 11-year period. This ratio of removals to net growth is somewhat higher than that for growing stock because removals concentrate on larger trees.

Gross sawtimber growth averaged 1,329 million board feet annually. Sawtimber ingrowth is the volume in softwood trees that became 9 inches dbh and the volume in hardwood trees that became 11 inches dbh during the period between surveys. The split between sawtimber ingrowth and accretion was quite different than that for growing stock. For sawtimber ingrowth was higher than accretion because of the maturation of a large amount of growing-stock ingrowth experienced before the 1968 survey. The bulge of timber volumes shown in the diameter-class distribution (Fig. 8) is moving into the sawtimber sizes.

Gross sawtimber growth has been reduced by about a quarter due to cull increment and mortality. As with growing stock, sawtimber mortality was much greater than cull increment.

Trend-Level Growth and Removals

So far, we have been concerned with average annual change rates for the period between surveys. Sometimes current change rates are more useful. To satisfy these needs, trend-level change rates are provided.

Trend-level change rates, which are used to estimate current change rates, are developed using a compound change function. It is assumed that the timber inventory has been increasing at a compound rate; that is, a constant change rate applied to a volume that increases yearly. The following estimates as-

sume that the 1978 inventory change and its components are consistent with the trend between surveys (Table 10)

In 1978, trend-level or current net growth was 314.5 million cubic feet of growing stock, while removals were 91.5 million cubic feet. Trend-level net change (net growth less removals) was an increase of 223 million cubic feet. For sawtimber, trend-level net growth was 1,120.9 million board feet, and removals were 409.5 million board feet, indicating a trend-level increase of 711.4 million board feet for 1978.

Timber removals were 29 percent, and mortality was 17 percent of the net growth of growing stock. Sawtimber removals and mortality were somewhat higher, 37 and 23 percent of net sawtimber growth, respectively. These rates differed considerably among the major species.

Oaks and hickories accounted for 41 percent of the 1979 growing-stock volume. They showed below average growth (32 percent of total growth) and, below-average mortality (27 percent of total mortality), and supported a large portion of the removals pressure (55 percent). The oaks and hickories had the highest removals/growth ratio; over half of their net growth was removed. Removals pressure was greatest for northern red oaks and the other red oaks and was least for hickory and the select white oaks. Mortality was highest for chestnut and post oaks, accounting for 15 percent of their gross growth.

Hard maple, white ash, black cherry, and yellow-poplar are growing at a faster rate and have had considerably less removals pressure than the oaks. Only 16 percent of the hard maple net growth of growing stock was removed in 1978. Mortality for hard maple and yellow-poplar has also been very low. Softwoods have also shown high growth rates, low removals pressure, and low mortality. Timber volumes have more than doubled since 1968. Additional information on volume changes may be found in the Timber Volume section of this report.

Timber Products

Timber products output data are based on a canvass of all primary wood-product manufacturers that used wood grown in Ohio. The data reflect production for 1 year, 1978, and therefore may not equate with the average annual removals data in this report. Additional information on timber products may be found in "Forest Statistics for Ohio—1979" (Dennis and Birch 1981) and in "Ohio Timber Industries—A Periodic Assessment of Timber Output" (Nevel and Redett 1980).

The total output of timber products was 108 million cubic feet in

Table 10.—Trend-level annual net growth, removals, and mortality of growing stock on commercial forest land, by species, Ohio, 1978

Species	Net growth	Timber removals	Mortality
	(Million cubic feet)		
Total softwoods	25.0	4.5	3.0
Soft maple	17.4	3.7	.6
Hard maple	27.0	4.4	1.4
Hickory	17.7	7.7	2.8
Beech	11.3	4.4	.9
Yellow-poplar	30.6	6.6	.5
Select white oaks	31.4	13.6	3.4
Select red oaks	12.7	7.7	1.4
Chestnut and post oak	13.2	6.9	3.5
Other red oaks	25.6	14.7	3.9
Ash, black cherry, and black walnut	47.9	7.8	7.1
Other hardwoods	54.7	9.5	26.1
Total hardwoods	289.5	87.0	51.6
Total all species	314.5	91.5	54.6

1978, 10 percent less than the 119.4 million cubic feet produced in 1966 (Table 11). Use of residues increased substantially even though sawlog production, the major source of residues, declined. New technology for manufacturing products from residues, high energy and transportation costs, and environmental concerns associated with residue disposal prompted firms to seek a more efficient use of the timber resource. Many operators also turned to smaller trees and nongrowing stock sources in an effort to fully utilize the available resource. Advances in whole-tree chip harvesting have made this more profitable.

Poletimber trees and other roundwood sources make up a greater portion of the output than they did in 1966. This and increased residue use slackened the pressure on the growing-stock inventory, particularly in the sawtimber sizes. Output derived from growing-stock sources dropped 20 percent, while total output fell only 10 percent since 1966. The proportion of output coming from rough and rotten or dead trees remained stable.

Sawlogs

Sawlog production declined since 1966 but is still the largest use of wood in Ohio (Table 12). At 322 million board feet, it accounts for more than half the state's roundwood output. Most of the small sawmills that arose during the early 1940's have been displaced by large, high-production mills. The number of sawmills decreased from 1,644 in 1947 to 326 in 1978, while sawlog production declined by a relatively small amount.

Oak was the major sawlog species. Its proportion of the total increased since 1966 and now accounts for more than half the sawlog harvest. Twenty-eight percent of the harvest was red oak, and 23 percent was white oak. On the other hand the proportion of maple has declined from 14 percent in 1966 to 9 percent in 1978. This decline helps to explain the large increase in maple volume experienced between the two timber inventories.

Two-thirds of the sawlog harvest came from the Hill Region. This proportion coincides with the distribution of total sawtimber volume and commercial forest land between the regions. Each region is contributing a roughly equivalent sawlog harvest per acre of forest land.

Table 11.—Output of timber products by source of material, Ohio, 1966 and 1978

Source	1966		1978	
	Million cubic feet	*Percent*	*Million cubic feet*	*Percent*
Growing-stock trees:				
Poletimber	7.0	6	9.7	9
Sawtimber	80.4	67	60.5	56
Total growing stock	87.4	73	70.2	65
Rough and rotten trees[a]	1.8	2	1.5	1
Salvable dead trees[a]	6.3	5	5.5	5
Other roundwood sources[b]	9.3	8	10.4	10
Total roundwood output	104.8	88	87.6	81
Manufacturing residues	14.6	12	20.4	19
Total output	119.4	100	108.0	100

[a] On commercial forest land.
[b] Includes trees less than 5.0 inches dbh, tree tops and limbs from commercial forest areas, or any material from noncommercial forest land or nonforest land such as fence rows and suburban areas.

Table 12.—Output of timber products by type of product and source, Ohio, 1978

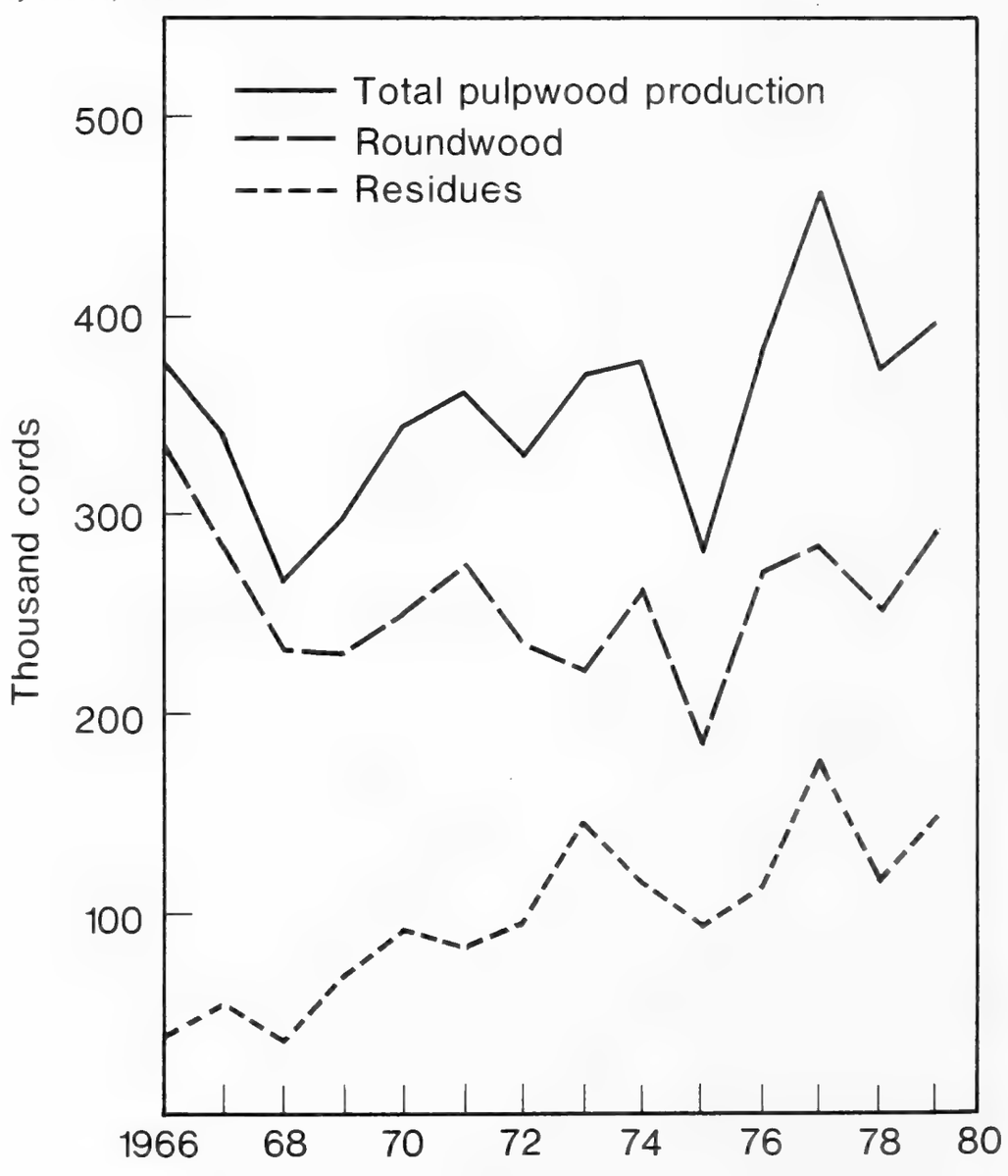
Product	From roundwood	From residues	Total
	(Million cubic feet)		
Sawlogs	47.3	—	47.3
Pulpwood	21.4	10.2	31.6
Fuelwood	13.6	6.1	19.7
Other	5.3	4.1	9.4
Total	87.6	20.4	108.0

Pulpwood

Pulpwood production increased slightly over the past decade, 31.6 million cubic feet (371,600 cords) in 1978 (Nevel and Bones 1978) (Fig. 11). However, the pulpwood harvest actually decreased. The trend is toward the increased use of manufacturing residues, primarily from the sawmill industry, for pulpwood production. Residues accounted for about a third of the 1978 production, up from the 10 percent used in 1966. In 1978, poletimber-size trees and other roundwood sources (Table 11) were a greater portion of the roundwood output than in 1966. Whole-tree chip harvesting made use of these sources more practical.

More than 90 percent of the pulpwood harvest came from the Hill Region. The South-Central Unit dominated with 103,500 cords in 1978. The primary species were oaks and hickory, which together made up 59 percent of the total pulpwood harvest. Softwoods, entirely pine, were only 2 percent, and assorted other hardwoods including maple, beech, and yellow-poplar accounted for the remaining harvest.

Figure 11.—Pulpwood production in Ohio by source, 1966–79.



Fuelwood

High energy costs have focused attention on wood as an alternative fuel. In 1978, fuelwood output increased to 19.7 million cubic feet, 18 percent of Ohio's total timber products output. Almost a third of the fuelwood was from manufacturing residues. This is a lower percentage of the total fuelwood output than that from residues in 1966. More residues are now used for pulpwood or other products and therefore do not find their way into the boiler. The increase in fuelwood output is primarily from roundwood harvesting. Fuelwood harvesting has increased from 8 percent of the roundwood harvest in 1966 to 15 percent in 1978 as more households and businesses turn to wood in an effort to cut fuel costs.

Many homeowners have turned to fuelwood in an effort to cut fuel costs.

Other Products

In 1978, other timber products accounted for 9 percent (9.5 million cubic feet) of Ohio's timber products output. Veneer log production, mostly used to make face veneer for furniture and veneer for wooden containers was 1.1 million cubic feet. White oak accounted for almost half of Ohio's total veneer harvest, much of which was shipped to other states for manufacture.

Cooperage production, mostly white oak staves for bourbon barrels, was just over 1 million cubic feet in 1978. High quality, defect-free bolts are required to manufacture cooperage staves.

A diverse group of other timber products collectively account for the remaining 7 percent of Ohio's timber output. Included in this group are posts, mine timbers, handle stock, metallurgical wood, fiber products, and a few other minor products.

Timber Outlook

We have witnessed an increase in forest-land area and a building of timber inventories over the past few decades. While analysis of what has happened is no small task, predicting the future is questionable at best. Projections are heavily influenced by assumptions that must be made concerning future events and behavior. Timber inventories are affected by a myriad of natural, economic, and sociologic forces, none of which can be known for certain. Education, experience, and consultation played a part in developing the following projections. Assumptions are stated clearly so readers may judge for themselves the likelihood that the projections will come true.

Commercial forest-land area increased over the past few decades, mainly due to reversion of marginal farmland. There was a 21.5 percent increase in commercial forest area between 1952 and 1968, and a 5.5 percent increase between the 1968 and 1979 surveys. The trend is slowing down. Continued increase but at a much reduced rate is expected for the near future. Over the long-term agricultural development, reservation of land for recreation, urban and suburban expansion, strip mining with reclamation to grass, and other factors are expected to offset and perhaps outweigh future gains in the commercial forest base. Therefore, in 30 years, the area of commercial forest is expected to be much the same as it is today. Change in commercial forest area is not expected to significantly influence the projection and will be held constant over the period.

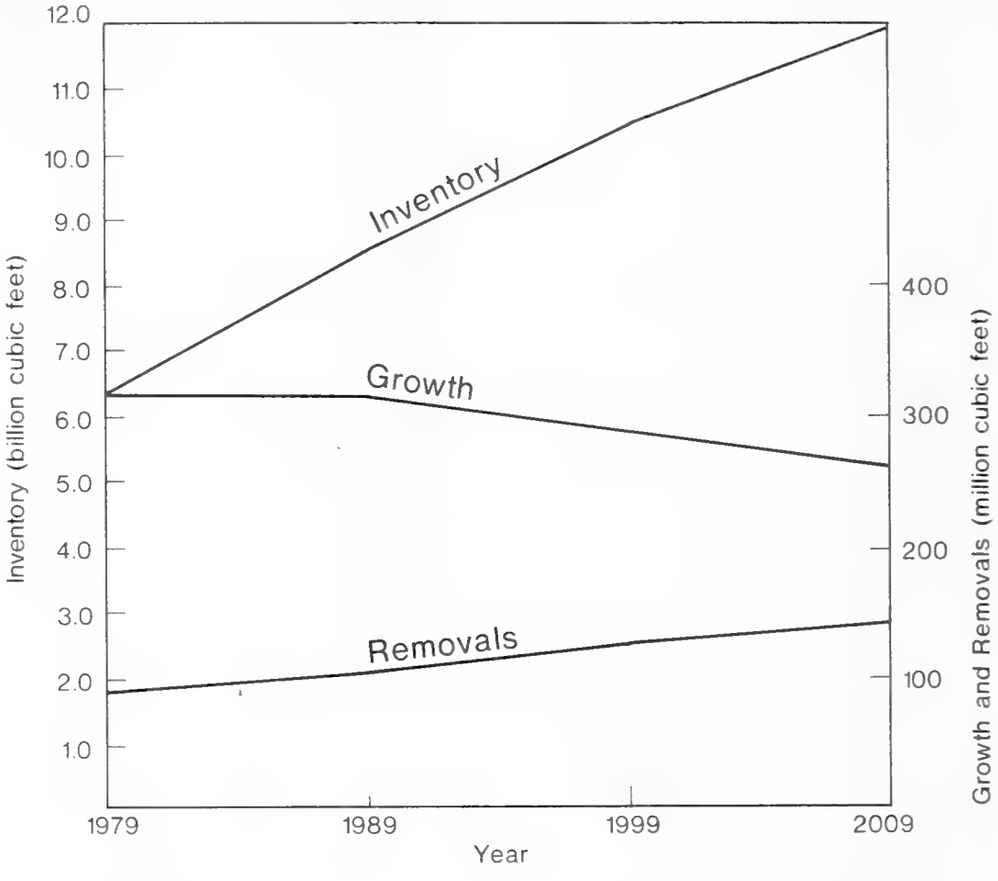
Average annual timber removals were 90.6 million cubic feet between 1968 and 1979. Trend-level removals were 91.5 million cubic feet for 1979. Although removals have decreased since the 1968 survey, they are expected to increase over the long term. We assumed that removals would increase at an annual rate of 1.5 percent over the next 30 years. Removals may increase be-

cause of industrial expansion in response to increasing inventory levels, increased demand for fuelwood, and substitution of wood products for more energy demanding materials.

Net growth is currently estimated to be 314.5 million cubic feet per year, which is an average growth rate of 45 cubic feet per acre for Ohio's commercial forest land. This growth is expected to continue over the next decade and then begin to decline to 38 cubic feet per acre by 2009 as the forest passes through its current stage of vigorous growth. As stands become older, growth will begin to slow and mortality will increase, particularly if the gypsy moth finds its way into Ohio. In 30 years, Ohio's stands are expected to have roughly the same stand-size structure that Pennsylvania has today. Growth is currently 38 cubic feet per acre in Pennsylvania.

In summary, to project the timber outlook we assumed that commercial forest area would not change significantly, removals would increase at 1.5 percent each year, and net growth would remain at present levels over the next decade and then begin to decline over the last 20 years of the projection period. The projection based on these assumptions reveals that inventory levels will build to almost 12 billion cubic feet by 2009 (Fig. 12). Net growth will exceed removals throughout the projection period, however, the margin will decrease as net growth slows and removals increase. Volumes, growth, and removals will be affected differently depending on the region, species, and other variables. Insight into these differences as they pertain to the projection may be obtained through review of other sections of this report.

Figure 12.—Projection of net growth, removals, and volume of growing stock on commercial forest land in Ohio, 1979–2009.



Ohio's Nontimber Forest Resources

Ohio's forests supply many benefits to landowners and citizens other than those related to timber production. Landowner studies show that nontimber values are most important to many landowners. Political activity and growth of organizations that express concern for wildlife, wilderness preservation, water quality, and erosion control illustrate an awareness of the importance of our nontimber resources. Strip-mining activity and participation in outdoor recreation clearly demonstrate the importance of other nontimber forest resources in Ohio.

The forest ecosystem is complex; its resources are interrelated and must be considered in that light. For ease of presentation, however, the different forest resources will be discussed individually.

Soil

Soils are the very foundation of the forest resource. Soils serve as a rooting medium that provides trees and other vegetation with support, water, and nutrients essential for growth. The relative availability of these elements in a particular soil influences the type of vegetation and its growth rate. Soil also provides a medium for many micro and

macro organisms that benefit tree growth. Mycorrhizal fungi extend the effective root zone and increase growth potential. Other symbiotic relationships exist between trees and soil-dwelling organisms.

To understand how soils affect forest stands, a knowledge of soil characteristics and soil formation is helpful. Soil is a dynamic natural body made up of four major components: mineral or parent material, organic matter, water, and air. Its properties have evolved due to the integrated effect of climate and living matter acting upon parent material, as conditioned by relief (Brady 1974). Soil formation, particularly weathering of parent material, is a very slow process.

Parent material plays an important role in determining soil characteristics. Ohio is entirely developed upon sedimentary rock: stratified deposits of clay beds, sand, and limestone that were deposited in a prehistoric sea. Generally, the western half of the state is underlain with limestone, while the eastern half is underlain with sandstone and shale. The only igneous and metamorphic rocks found in Ohio were brought in from the north by glacial action. Glaciers transported and deposited much glacial till, which is quite variable, especially as to size of particles. These deposits are called moraines. Ground moraines, fairly level deposits laid down as the ice front retreated, occur over a wide area and are agriculturally very important. Glacially supplied parent materials are geologically fresh. The young soils derived from this parent material are not drastically leached and generally are higher in available nutrients. Drainage is also important in determining the productivity of these soils. Some are made up of stratified layers of sandy gravel that drain easily, while others have fragipans (dense, impermeable layers) that limit drainage. Poorly drained soils may restrict the amount of oxygen available to the roots and limit growth or eliminate certain types of vegetation from the site. Many forest stands occur on land where poor drainage has inhibited or prevented its use for agricultural crops. Very poorly drained soils may be unable to support roads or recreational development.

Plants obtain moisture from the soil for growth and survival. The amount of precipitation retained in the soil against the force of gravity and available to plants depends upon the physical properties of the soil. Texture, structure, and density affect moisture holding ability. A coarse-textured sand will have a low moisture retaining ability, while a fine clay will retain much moisture but may be poorly aerated. Soil depth and structure also affect soil moisture retention.

Vegetation also affects soil development. Leaves and twigs deposited on the soil surface decompose and enrich the upper soil layers. In this way, vegetation returns nutrients from the root zone to the soil surface, which inhibits leaching. Different organic matter distributions exist under grassland and forestland conditions. Much of the organic matter found in grassland soils comes from the annual death of grass roots, while little organic matter is added annually by tree roots.

Good forestry and agricultural practices help eliminate soil erosion such as this.

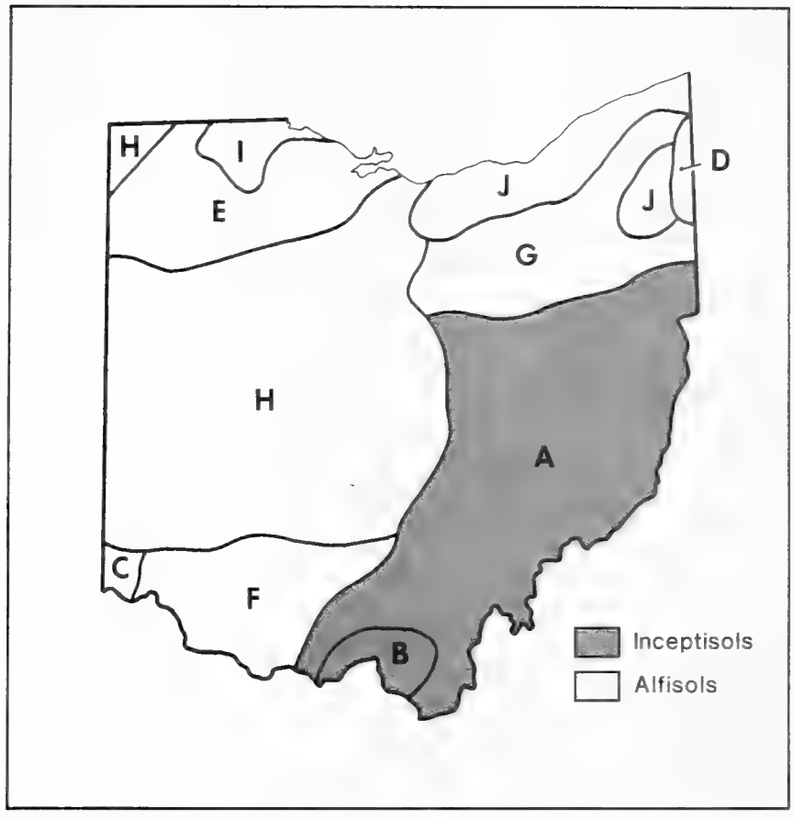
This photo was taken in 1946.

Local soil conditions are highly influenced by topography. Topography influences soil through moisture and temperature relations, soil movement and water movement both over and in the soil. Steeper soils are usually drier with less leaching, less vegetation, lower organic matter content and are shallower than those found on lower slopes and bottomlands. Erosion due to water runoff is also greater on steeper slopes.

Differences in parent material, topography, and other factors affecting soil development can change over relatively short distances. These changes are reflected in vegetative diversity. Local soil conditions may vary considerably, but a generalized soils map can be useful (Fig. 13).

The Hill Region is characterized by Inceptisols, which are immature soils having weakly expressed profile features and retaining close resemblances to the parent material. Clay accumulation is generally absent, hindering moisture retention. These soils are not as productive as the Alfisols found in the Glaciated Region and often have been allowed to reforest following periods of agricultural use.

Figure 13.—The soils of Ohio.



Order: Inceptisols

Suborder: Ochrepts

Great group:

A— Dystrochrepts, steep, plus Hapludalfs and Hapludults, both moderately sloping.

B— Dystrochrepts plus rock land and Hapludults, steep.

C— Eutrochrepts, steep.

D— Fragiochrepts plus Fragiaquepts and Dystrochrepts, moderately sloping.

Order: Alfisols

Sub-order: Aqualfs

Great Group: .

E— Ochraqualfs plus Haplaquepts and Hapludalfs, gently sloping.

Sub-order: Udalfs

Great group:

F— Fragiudalfs plus Fragiaqualfs and Hapludolls, gently sloping to steep.

G— Fragiudalfs plus Ochraqualfs and Fragiaqualfs, gently sloping.

H— Hapludalfs plus Argiudolls, gently sloping.

I— Hapludalfs plus Haplaquolls and Udipsamments, gently sloping.

J— Hapludalfs plus Ochraqualfs, gently sloping.

More productive soils, Alfisols and Ultisols are often found in the bottomland areas of the Hill Country. These soils comprise the region's more productive forest and agriculture land.

Alfisols, which are moist mineral soils that appear to be more strongly weathered than the Inceptisols, characterize the Glaciated Region. These soils are mostly formed in humid areas under native deciduous forests. Alfisols typically have subsurface horizons of clay accumulation. This indicates a high moisture retention ability but may also inhibit drainage. The relatively high base status of these soils indicates high productivity where drainage is not a problem. Ohio's best agricultural soils are Alfisols.

Water

Water is essential for all forms of life. It also provides many recreational opportunities and soothing esthetic qualities as well as industrial and transportation uses. Water can also be devastating. Severe floods and erosion have caused much hardship. Forests play an important role in enhancing water-related benefits and at the same time minimize its destructive effects.

Forest cover helps prevent the devastation caused by floods such as this.

Average annual precipitation is 39 inches in Ohio. Many factors influence what will become of this moisture. Different forms of precipitation vary in their effectiveness in replenishing soil moisture supplies that are available for plant growth. Timing is important. Winter snow and rain come during the season of minimum plant growth. This precipitation does, however, recharge soil moisture bringing it to levels favorable for spring growth. Vegetation also has an effect because it intercepts part of the precipitation, allowing moisture to evaporate directly into the atmosphere and preventing it from reaching the soil. This effect varies considerably depending on the type and amount of vegetation and the severity of the storm. Hardwoods generally intercept less of the year's precipitation than conifers because hardwoods do not retain their foliage during the winter. Also, the relative amount of moisture reaching the soil increases as the amount of precipitation received by a particular storm increases.

Once it reaches the soil surface, precipitation either infiltrates the soil or runs off as surface flow. The relative amounts of each depend upon the form of precipitation and the type and condition of the ground cover and soil layers. Runoff has two serious consequences: not only are plants denied this moisture supply, but valuable topsoil may be lost due to erosion. Erosion is greatly reduced by vegetative cover. Very little erosion typically occurs in an undisturbed forest. Layers of vegetation and the litter layer reduce the force of the rain reaching the soil surface. This reduces the amount of soil particles dislodged by force and carried away. Clear water also infiltrates better because it does not block soil pores. Less surface flow occurs and less soil is carried off in whatever surface flow that does occur under a full vegetative cover.

Much of the moisture retained in the soil is absorbed by tree and plant roots and returned to the atmosphere as water vapor. This transpirational use of water by the forest is generally 40 to 60 percent of the annual precipitation. Transpirational use of water can be altered through changes in the forest cover. Generally, cutting trees reduces transpiration and interception losses and makes more water available to replenish both ground and surface waters. Good harvesting practices are essential if water quality is to be maintained. Poor logging practices, especially with respect to logging roads, can increase stream turbidity drastically. Particular care must be taken along streams; removal of streamside vegetation invites erosion and disruption of the water course. It may also allow sunlight to reach the water surface and raise water temperature. Changes such as these can seriously harm many forms of aquatic life. Carefully planned and executed logging operations can be beneficial in increasing water yield and providing timber products while maintaining water quality.

Water that infiltrates the soil and is not retained in the soil replenishes ground water and eventually surface flows such as streams and lakes. This water is cleaner and more evenly supplied than runoff. Forests, through their tempered release of clean water, do much to improve water quality, reduce flooding, and eliminate erosion.

Ohio has two major drainage basins: Lake Erie, which drains over a quarter of the state, and the Ohio River, which drains the remainder. The divide between the two drainages is a low ridge extending southwest from Trumbull County to Mercer County.

The Lake Erie basin includes 7.5 million acres in Ohio (U.S. Army Corps of Engineers 1979). The Maumee River, which enters the lake at Toledo, is the largest river basin tributary to Lake Erie, draining 4.2 million acres. Other basins draining into Lake Erie are those of the Portage, Sandusky, Huron, Vermilion, Black, Rocky, Cuyahoga, Chagrin, Grand, and Ashtabula rivers. Large metropolitan areas dominate the lake shore. This basin is primarily agricultural and less forested than most other parts of the state. Many streams, particularly in the more level and less forested western area, are sluggish and carry heavy silt loads.

The Ohio River basin includes the remaining 18.7 million acres, which vary more in topography and have more forest cover than those in the Lake Erie basin. The Ohio River forms the entire southern border of Ohio (436 miles). Many industries located along the river depend on it as a water supply and transportation route. The Corps of Engineers began improvement of navigation on the Ohio River in 1825. This work has continued, and today the entire river has been improved by construction of locks and dams to provide a channel depth of 9 feet.

Many other water related construction projects have been completed across the state. Eighty-three of Ohio's 110 lakes are manmade. They serve to improve water quality, aid in flood control, and provide recreational opportunities and other benefits. Although many projects are multipurpose, flood control has been the overriding theme in Ohio. Devastating floods occurred in 1913, 1927, and 1936 following the removal of much of Ohio's forests. These floods quickly indicated the need for flood control projects and the importance of forests in tempering flow.

Coal

Coal is an important resource in Ohio. Bituminous coal production, 43.5 million short tons in 1979, ranks fifth in the nation (U.S. Dep. Energy 1981). Recoverable coal reserves are estimated at just over 1 billion short tons. This represents the quantity of coal that can be recovered from existing coal reserves at reporting mines. Recovery of these reserves will impact the forest resource. Its affect will depend on the mining methods used, reclamation procedures, and other related factors.

One-third of Ohio's coal production is from underground mining concentrated in six counties. Ranked by 1979 production these are: Belmont, Meigs, Harrison, Perry, Monroe, and Vinton counties. Areas of direct impact are mine openings, storage points, waste dumps, and haul roads. While these may be locally significant, they do not have a great impact on the state's total forest resource. Indirect impacts on the forest resource such as soil erosion, disruption of drainage patterns, subsidence, and stream pollution can be severe.

Surface mining, which accounted for two-thirds of Ohio's 1979 coal production, has a much greater impact on the forest resource. Increases in coal demand and improvements in mining technology increase the potential for strip-mine disturbance. Gigantic earth-moving machines can quickly mine large areas and make previously uneconomical operations profitable. Some previously mined areas are being revisited to recover deeper coal seams that could not be economically reached in the past. Surface mining obviously impacts the mining sites by removing the soil and all that exists above it. However, its influence is more widespread. It also influences management on land that has strip-mining potential. Forest management is futile on land that will probably be subjected to surface mining and may be questionable on land that has coal-mining potential. This is further complicated by division of the ownership of mineral rights and land. Mineral rights may and often are held by owners who have little interest in the forest or even in the long-term productivity of the land.

Gigantic earth-moving machines increase the potential for disturbance from strip-mining operations.

Surface mining occurred in 22 eastern counties in 1979 and was particularly concentrated in the East-Central Unit, which accounted for three-quarters of the state's surface mine production. The long-term impact that surface mining will have on the forest resource is determined by the method used to reclaim the land. Fifteen years ago, trees were the primary tool used in reclamation (Kizer 1980). Today only 10 percent of the mining permits show forest land as the postmining land use, and even these may be modified to exclude tree planting. The reasons for this change follow.

A strip-mined area reclaimed to grass in Muskingum County.

The 1972 Ohio Strip Mine Law provided the option of revegetating strip-mined land with a heavy cover (75 percent) of grasses and legumes or a lighter cover (50 to 60 percent) if trees were planted. This law drastically altered reclamation site conditions (Smith 1980). New mining, grading, and topsoil requirements brought about higher soil pH levels, improvements in amounts and availability of nutrients, and a decrease in toxicity levels. The topography became almost entirely traversable by rubber-tired equipment. However, erosion and the resulting sedimentation were still problems. These concerns played a major role in the design of the 1972 law, which allowed for herbaceous cover to combat erosion. Pollution abatement was a prime concern of the 1972 law.

Tree planting became an additional and often unnecessary expense to the operator. The additional grading requirements of the 1972 law caused more soil compaction, which hindered tree planting and survival. Competition from the grasses and legumes needed for erosion control also reduced survival rates for tree seedlings. Repair work required to meet regulations was more complicated for trees than for grasses and legumes. One complication is that tree seedlings must be planted in the spring. Seeing the more rounded contour of the reclaimed land, landowners saw advantages in having grass cover for pasture and forage production. These reasons contributed to the decline of tree planting on reclamation sites. However, reclamation to grassland may cause problems other than those associated with the obvious loss of valuable forest area. Establishment of grasses on very acid soils requires heavy applications of lime and fertilizer (Gebhart 1980). Reapplication is often required to sustain this cover. However, the operators are responsible only until their bond is released and if they do not own the land, will lose interest in it. The landowner may not continue this care, particularly if he or she is not making a profit from the land. If this happens, the cover may begin to thin and subject the soil to erosion.

A few steps have been taken to encourage tree planting. The required vegetative cover may be reduced to 50 percent if trees are planted. Tree survivial is increased with less vegetative cover, and operators have more incentive to plant trees. Also, the Ohio Division of Reclamation is requiring that vegetation remain successful for 5 years. In some areas, this is more difficult for grasses and legumes, so tree planting may be more advantageous in meeting this requirement. Changes in land use from forest to grassland are discouraged by requiring public notice, landowner consent, and impact statements from cooperating agencies. Time is money and operators want to avoid these delays whenever possible. Research is being conducted to overcome some of the technical problems associated with tree planting and survival on reclamation sites. These measures have been somewhat successful in encouraging tree planting. Between 1972 and 1977, only 1 percent of the postmining land use was forest land. Today it is 10 percent.

Many areas have been successfully reclaimed by tree planting. This is evidenced by the rapid increase in black locust stands found in the East-Central Unit. Strip mining will always impact the forest drastically during the mining effort, however, with proper reclamation the long-term outlook for the forest resource can be quite good. One advantage is that preferred species can be planted. On favorable sites, timber production can produce pulpwood in 20 to 25 years and sawlogs in 30 to 40 years (Davis and Davidson 1968). Another advantage is that roads constructed for coal removal can later provide access for management and harvesting of trees and for recreation. All this depends upon a conscientious effort to reclaim the land properly. Government agencies, coal companies, independent operators, and landowners are concerned and should work toward this end.

Recreation

Recreation is defined as a refreshment of strength and spirits after work. It is vital in the tension-filled society in which we live. Forests provide marvelous opportunities for various forms of outdoor recreation. Many of Ohio's residents and landowners consider recreation to be the most important benefit they receive from the forest. Viewing the forest or just knowing it exists provides satisfaction and contentment to many. Some forms of recreation, such as water-related activities or wildlife viewing, may be experienced outside the forest setting but are highly dependent on the forest's influence.

Ohio's outdoor recreation opportunities include hiking, horseback riding, camping, picnicking, hunting, fishing, sightseeing, various winter sports, and a variety of others. There are 19 state forests managed by the Ohio Department of Natural Resources, Division of Forestry, for multiple uses, which certainly include recreation. These forests total 170,000 acres, not all of which are forested. In addition, there are 71 state parks and 100 state wildlife management areas, which also provide recreational opportunities.

The Wayne National Forest is also managed for multiple uses. In 1979, the National Forest received over 360,000 visitor days of outdoor recreational use. Hunting was by far the most popular with 115,000 visitor days, while camping was a distant second with 41,000 visitor days spent in the forest's three camping areas.

Counties and municipalities own an additional 26,000 acres of park land. Much of this land is classified as reserved forest land and is managed primarily for recreational use.

Although it includes many fine recreational sites, public land is only a small portion of Ohio's forest base. Much outdoor recreation occurs on private land. Approximately a third of Ohio's private woodland owners indicated that recreation or esthetic enjoyment was the primary benefit they receive from their forest land. Many landowners, 29 percent, allow some public recreation on at least a portion of the 2.3 million acres they own. Hunting and hiking are the most frequent recreational activities on private land. Private land has a tremendous potential to supply recreational opportunities to Ohio's residents. However, the large number of owners and their diverse interests make planning difficult.

Enjoyment of the forest setting.

Urban Forestry

As previously mentioned, individual trees and small wooded areas often provide recreational opportunities, esthetic relief, and important wildlife habitat, particularly in urban areas. During the past decade, urban forestry has grown rapidly; Ohio currently leads the nation with 35 "Tree City USA" designations. Comprehensive programs designed to educate urban populations on the role of trees and other vegetation in their environment have cultivated an interest in urban forestry. This interest can be an important catalyst in bringing information about environmental programs to the public.

Fish and Wildlife

Fish are dependent on the forests for a clean water supply. Fish are sensitive to pollution and are sometimes used as indicators of water quality. Well-managed forest land reduces erosion, tempers flows, and provides shade that prevents water temperatures from rising above the tolerance limits of coldwater fish. Forests also provide habitat for insect populations upon which fish feed.

Well-managed forest land reduces erosion, tempers flows, and provides shade, helping to make scenes such as this possible.

(Photo by Ron Keil, Ohio Dep. Nat. Resour.)

Black Bullhead.

(Photo by Al Staffan, Ohio Dep. Nat. Resour.)

Ohio has approximately 7,000 miles of fishable streams and rivers and over 200 lakes (personal communication, Clayton Lakes, Ohio Dep. Nat. Resour.). Lake fishing is most popular in Ohio. The vast majority of Ohio's lakes are manmade; there are only 27 natural lakes.

The importance of fishing is illustrated by the sale of over 900,000 licenses in both 1979 and 1980. This figure was expected to reach the 1 million mark by 1981, which would generate well over $7 million in revenue. To help meet the high fishing demand, there are six state and two federal fish hatcheries in Ohio. In 1980, over 26 million fish were stocked into Ohio's fishing waters. These included: walleye, muskellunge, northern pike, channel catfish, trout, Coho salmon, yellow perch, striped bass, largemouth bass, smallmouth bass, and a few others.

As stated earlier, pollution is the biggest threat to fish populations. Sedimentation, acid-mine drainage, industrial waste, and acid rain are but a few of the many threats to high water quality. Forests cause none of these problems and do much to improve water quality and improve habitat for fish and many other forms of aquatic life.

Many wildlife species depend on the forest for food or shelter. Wildlife is generally divided into two groups: game and nongame species. The major game species are white-tailed deer, turkey, fox and gray squirrels, cottontail rabbit, ruffed grouse, pheasant, and various waterfowl. The sale of 460,000 hunting licenses and 215,000 deer licenses in 1980 is evidence of the popularity of this sport in Ohio.

The increase in forest land over the last several decades has been very beneficial to many wildlife species. The white-tailed deer, which had virtually disappeared from Ohio by 1904, is now plentiful across the state. Substantial increases in the

White-tailed deer, now plentiful in Ohio.

(Photo by Al Staffan, Ohio Dep. Nat. Resour.)

An active livetrap and transplant program and improved forest habitat has enabled wild turkey populations to build.

(Photo by Ron Keil, Ohio Dep. Nat. Resour.)

deer herd occurred in recent years. Relatively mild winters, good habitat conditions (reverting fields), and the short 5 day hunting season have contributed to this increase in deer populations. Short hunting seasons create a hit or miss situation influenced by weather conditions. The number of deer hunting licenses has increased from 175,375 to well over 200,000, and the number of antlerless permits issued has increased from 20,400 to 67,660 from 1978 to 1980. During this time, the deer harvest almost doubled, increasing from 22,000 to 40,500. Deer populations are relatively high, and hunting will continue to be popular in Ohio.

Wild turkeys, which disappeared by 1900, also returned. In 1956, wild turkeys were successfully reintroduced in Ohio. An active livetrap and transplant program has helped populations build. Turkeys are found in the eastern part of the state and are more numerous in the southeastern portion. More suitable turkey habitat is provided by large blocks of forest, particularly oak/hickory. These are more common in this portion of the state. Hunting seasons vary by county and may or may not open in a particular county depending upon population estimates. The turkey harvest has more than tripled from 167 in 1978 to 569 in 1981.

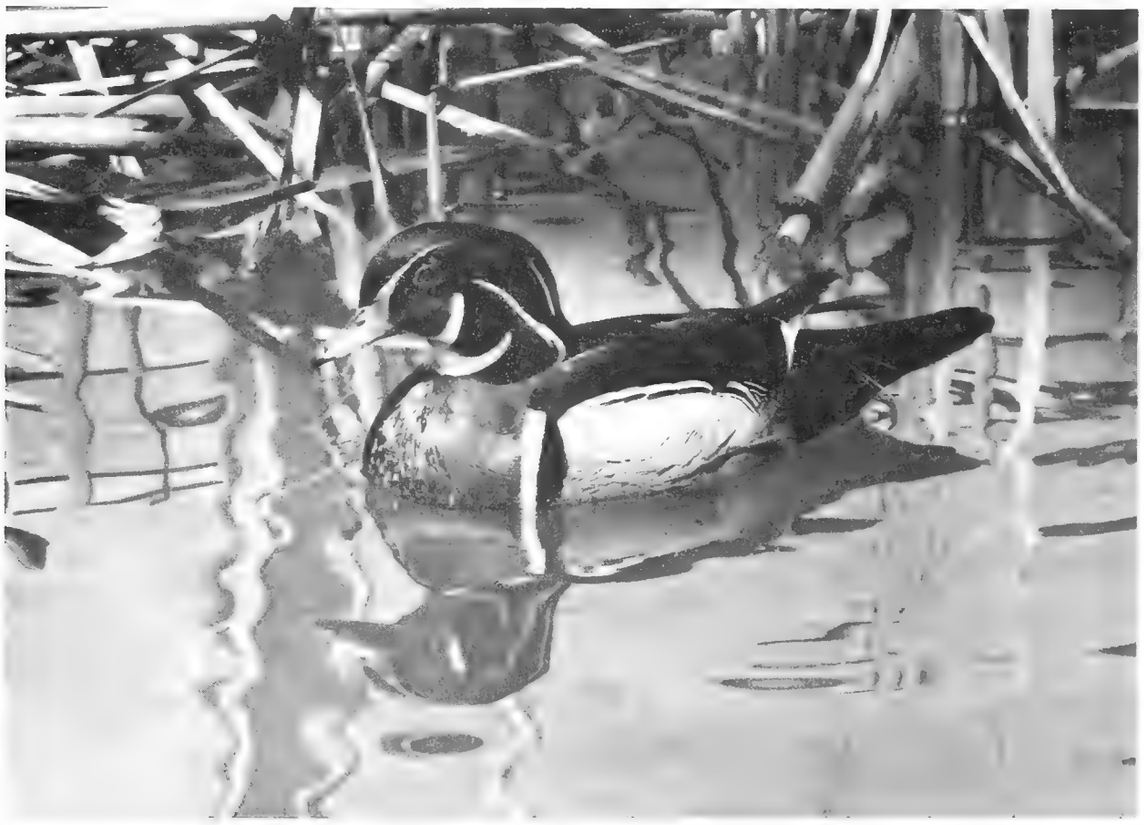
Small game animals such as fox and gray squirrels, cottontail rabbits, ruffed grouse, and pheasants are also quite popular. Squirrel and rabbits are found throughout the state, but grouse are found only in eastern Ohio. Grape thickets and aspen are preferred by grouse. Pheasants are more restricted to the Glaciated Region, preferring more open agricultural areas. They do, however, use forest habitats for cover.

Muskrats are the most popular furbearer, followed closely by fox, in Ohio. Other animals that are trapped for their fur include raccoon and beaver. Beavers, which had virtually disappeared, were trapped and transplanted in the early 1960's and have been increasing, particularly in the Hill Region. Beaver trapping seasons and relatively small harvests have been gradually increasing in recent years. The red fox prefers the more open environment found in the Glaciated Region, while the gray fox is more a woodland creature.

The manner in which strip-mined land is reclaimed greatly influences wildlife habitat and has often been quite beneficial. Strip planting is particularly effective in improving wildlife habitat. Deer are often seen browsing on new growth in reclaimed areas. Turkeys also use reclaimed land as brooding areas. Young turkeys require a high-protein diet consisting mainly of insects, which are more available in cleared areas than in a mature forest. Strip mining and the abandonment of adjacent cropland have encouraged the increase in aspen that occurred in the East-Central Unit. The increase in aspen helps explain the relative abundance of ruffed grouse in that part of the state. However, reclamation of previously forested land with grass can be a significant and detrimental land use change for many forest wildlife species.

Pools and lakes that have developed in strip-mined areas, as well as the many man-made lakes, are good waterfowl habitat. These lakes make excellent stop-over and wintering habitat for ducks and geese. Geese are grazers and like the proximity of grass and water found in these areas. Improved habitat and stocking efforts have led to good progress in developing a Canada goose population. Wood ducks, on the other hand, are closely associated with forest habitat. They prefer swamps and rivers found in wooded areas and build their nests in hollow trees. Hunting pressure, spurred by the desirability of the wood ducks' colorful feathers, and loss of habitat once threatened this species existence in Ohio. Improved habitat and some protective measures have allowed populations to build. The wood duck is now relatively common, particularly in the forested Hill Region.

Wood ducks are closely associated with forest habitat.



(Photo by Al Staffan, Ohio Dep. Nat. Resour.)

Over 300 species of nongame birds are found in Ohio with approximately180 species nesting regularly within the state. Ohio's diversity of forest types and stand sizes is beneficial. Forest types found in Ohio contain many species of trees that form a varied habitat capable of supporting this wide variety of birds. Bird watching and appreciation of these creatures have increased tremendously.

Ohio is a home or stopping place for a few federally listed endangered species (Roth 1981). These include two species of bats: the Indiana bat and Virginia big-eared bat; and three raptors: the bald eagle, American peregrine falcon, and arctic peregrine falcon.

Forest Management Opportunities

The resilience of Ohio's forests has been demonstrated. They have rebounded from past abuses quite well, and volumes are increasing at a rapid rate. Future growth is expected to exceed future removals, and volumes will continue to build. Looking at total timber volumes on a state level, however, does not paint the whole picture.

Part of Ohio's timber volume is not available for harvest. Some because it is currently inaccessible, either due to lack of roads, steep terrain, or other physical barriers. Other timber is held by landowners who are not interested in harvesting any trees. Landowners who indicate they will never harvest timber hold 1.5 million acres of Ohio's commercial forest land. An additional 3.1 million acres is held by owners who indicate they may possibly harvest timber at some future date but do not have definite intentions to do so. Although we do not have an estimate of how much timber is unavailable for harvest due to inaccessibility or landowner attitudes, it is clear that these reasons do preclude some timber from harvesting. This, of course, will change over time, and much of this timber will be available at the right price with changes in ownership or with new logging technology.

Undesirable species, small size, or poor quality also limits the use of Ohio's timber volume for certain industrial uses. Continued removals and increased mortality from insect or disease problems may bring certain species such as oak into short supply. Overall, as far as meeting industrial demands in Ohio, the outlook is good. However, this does not mean that individual landowners or society as a whole will not benefit from improved forest management. There are many benefits that accrue from forest management activities in addition to improved timber output.

A forest management plan that includes harvesting mature timber can be quite beneficial in improving wildlife habitat (Shaw 1970, Roach 1974). Forest management plans may also be developed to tailor harvesting schedules to improve esthetic qualities, recreation opportunities, or water yield. Landowners may be able to obtain financial returns from timber harvesting, while at the same time improve upon other aspects of the forest resource.

Ohio's forests, for the most part, have developed without any effort toward intensive forest management. It is interesting to look a little deeper into the present condition of the forest and into what might be done to improve forest productivity.

Only 6 percent of Ohio's commercial forest land is poorly stocked, that is less than 60 percent of full stocking. However, this includes cull trees; when only growing-stock trees are considered, 18 percent of the land is poorly stocked and an additional 43 percent is only medium stocked (60–99 percent of full stocking). Removal of cull trees, thus providing additional space for growth of the more desirable trees, will improve stocking. Similar reasoning certainly applies to the removal of undesirable species. Much of this material can be used as fuelwood or other products, particularly those made from chips. As mentioned previously, technology for using lower grade material has improved immensely in recent years. Some cull or dead trees, however, should be left standing to provide valuable wildlife habitat. These trees often provide cavities that are used for nesting, winter cover, escape, food seeking and storage, or other uses.

To portray an overall picture of the timber management practices that would be recommended in Ohio, field crews classified each forested plot that they measured into a recommended-treatment class (Table 13). Almost half—3.1 million acres—of Ohio's commercial forest land is on schedule. This class includes land that is in good condition and would not be significantly improved by timber stand improvement cuttings. However, it also includes some marginal land that may not be in the best condition for wood production but because of its low production potential, does not merit any improvement work.

Our crews also estimated that almost 1.5 million acres need some timber stand improvement work if improved timber production is desired. These recommendations include: thinnings to stimulate the growth of the remaining trees and to increase total production, and improvement cuttings to remove trees of undesirable form or species.

Stands on just over 1.1 million acres need to be removed or thinned sufficiently to allow establishment of a new stand either by natural regeneration or planting. This recommendation applies to stands that are being taken over by undesirable species or are sufficiently understocked with desirable species to justify this treatment. It may also apply to stands that are not mature but should be removed to improve productivity. These recommendations are made purely from a timber production standpoint. Many of these stands may provide excellent wildlife habitat or other benefits in their current condition.

The remaining 1.1 million acres are mature and ready for harvest. Of course, it is not desirable or even feasible to harvest all this timber now, but it does indicate the general maturity level of Ohio's forests.

Survey field crews also determined a past-management class for each field plot (Table 13). Approximately two-thirds of the commercial forest land had no evidence of harvesting within the last 25 years. The remaining third had either been clearcut or selectively cut within the last 25 years. Compared to other groups, forest industry did a greater proportion of their harvesting by clearcutting. Farmers cut timber from almost as great a portion of their land but primarily used the selection method, which was also favored by the miscellaneous private group.

In conclusion, net growth is exceeding removals as timber volume builds. Although this trend is expected to continue there is room for improvement. Timber quality and species mix, wildlife habitat, recreational opportunities, and esthetic values can be improved through forest management. This will improve upon the qualiity of life in Ohio.

Table 13.—Area of commercial forest land by past-management class, recommended-treatment class, and ownership, Ohio 1979

(In thousands of acres)

Item	Other public	Forest industry	Other corporate	Farmer	Misc. private	Total
			PAST-MANAGEMENT CLASS			
Clearcut	—	66.7	40.6	166.1	164.0	437.4
Selective cut	81.1	5.9	36.1	944.1	673.8	1,741.0
No evidence harvest—25 yrs	171.8	105.8	460.6	1,778.7	2,050.1	4,567.0
Reserved by owner	—	—	—	—	12.4	12.4
Total	252.9	178.4	537.3	2,888.9	2,900.3	6,757.8
			RECOMMENDED-TREATMENT CLASS			
Harvest mature	90.9	32.2	81.1	466.2	425.5	1,095.9
TSI	53.2	50.9	103.3	552.5	697.2	1,457.1
Stand conversion	25.5	15.3	134.7	434.8	495.5	1,105.8
Stand on schedule	83.3	80.0	218.2	1,435.4	1,282.1	3,099.0
Total	252.9	178.4	537.3	2,888.9	2,900.3	6,757.8

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Appendix

Definition of Terms

Accretion. The estimated net growth of growing-stock trees that were measured during the previous inventory, divided by the length of the period between surveys. It includes the growth on trees that were cut during the period, plus those trees that died and were used.

Annual mortality trend-level. The estimated mortality of growing stock or sawtimber for a specific year (1978 for Ohio) based on average rates of diameter growth and mortality for the period. This estimate is consistent with the average annual change during the period between surveys and with the current inventory.

Annual net growth trend-level. The estimated growth of growing stock or sawtimber for a specific year (1978 for Ohio) based on average rates of diameter growth and mortality for the period. This estimate is consistent with the average annual change during the period between surveys and with the current inventory.

Annual removals trend-level. The estimated removals of growing stock or sawtimber for a specific year (1978 for Ohio) obtained from a trend line for the period. This line is established by fitting a curve to actual removals data for several years during the period. The actual removals for the year given can vary from the trend estimate because of fluctuations in market conditions and other factors.

Average annual net growth. The change, resulting from natural causes, in growing-stock or sawtimber volume of sound wood in growing-stock or sawtimber trees during the period between surveys, divided by the length of the period. Components of average annual net growth include the increment in net volume of trees that are present at the beginning of the period and that survive to the end (accretion), plus average annual ingrowth, minus average annual mortality, and minus the net volume of trees that became rough or rotten during the period (cull increment).

Average annual removals. The net growing-stock or sawtimber volume of trees harvested or killed in logging, cultural operations—such as timber stand improvement—or land clearing, and also the net growing-stock or sawtimber volume of trees neither harvested nor killed but growing on land that was reclassified from commercial forest land to noncommercial forest land during the period between surveys. This volume is divided by the length of the period.

Board foot. A unit of lumber measurement 1 foot long, 1 foot wide, and 1 inch thick, or its equivalent.

Coarse residues. Manufacturing residues suitable for chipping, such as slabs, edgings, and veneer cores.

Commercial forest land. Forest land producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre per year) and not withdrawn from timber utilization.

Commercial species. Tree species presently or prospectively suitable for industrial wood products. Excludes species of typically small size, poor form, or inferior quality, such as hawthorn and sumac.

County and municipal lands. Lands owned by counties and local public agencies or municipalities or leased to them for 50 years or more.

Cull increment. The net volume of growing-stock trees on the previous inventory that became rough or rotten trees in the current inventory, divided by the length of the period between surveys.

Diameter at breast height (dbh). The diameter outside bark of a standing tree measured at 4-1/2 feet above the ground.

Farmer-owned lands. Lands owned by farm operators, whether part of the farmstead or not. Excludes land leased by farm operators from nonfarm owners.

Federal lands. Lands (other than National Forests) administered by Federal agencies.

Fine residues. Manufacturing residues not suitable for chipping, such as sawdust and shavings.

Forest industry lands. Lands owned by companies or individuals operating primary wood-using plants.

Forest land. Land at least 10 percent stocked with trees of any size or that formerly had such tree cover and is not currently developed for nonforest use. The minimum area for classification of forest land is 1 acre.

Forest type. A classification of forest land based on the species forming a plurality of live-tree stocking. The many forest types in Ohio were combined into the following major forest-type groups:

a. *White/red pine*—forests in which white pine or red pine, singly or in combination, comprise a plurality of the stocking; in Ohio, common associates include yellow-poplar, red maple, oak, black walnut, and black cherry.

b. *Hard pine*—forests in which Virginia, shortleaf, or pitch pines or eastern redcedar, singly or in combination comprise a plurality of the stocking; in Ohio, common asso-

ciates include red maple, oak, white or red pine, white ash, black walnut, and sycamore.

c. *Oak/pine*—forests in which hardwoods (usually hickory or oak) comprise a plurality of the stocking but where shortleaf, Virginia or eastern redcedar comprise 25 to 50 percent of the stocking.

d. *Oak/hickory*—forests in which upland oaks, hickory, yellow-poplar, black locust, black walnut, sweetgum, sassafras, persimmon, or red maple (when associated with central hardwoods), singly or in combination, comprise a plurality of the stocking and in which shortleaf or Virginia pines, or eastern redcedar comprise less than 25 percent of the stocking; in Ohio, common associates include white ash, sugar maple, and black cherry.

e. *Elm/ash/red maple*—forests in which elm, river birch, sycamore, willow, cottonwood, or red maple (when growing on wet sites), singly or in combination, comprise a plurality of the stocking; in Ohio, common associates include white ash, sugar maple, oak, hickory, yellow-poplar, and black cherry.

f. *Northern hardwoods*—forests in which sugar maple, beech, yellow birch, black cherry, or red maple (when associated with northern hardwoods), singly or in combination, comprise a plurality of the stocking; in Ohio, common associates include white ash, hickory, yellow-poplar, white oak, and red oaks.

g. *Aspen/birch*—forests in which aspen comprises a plurality of the stocking; in Ohio, common associates include red maple, black cherry, red oaks, and beech.

Growing-stock trees. Live trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings; that is, all live trees of commercial species except rough and rotten trees.

Growing-stock volume. Net volume, in cubic feet of growing-stock trees 5.0 inches dbh and larger, from a 1-foot stump to a minimum 4.0-inch top diameter outside bark of the central stem, or to the point where the central stem breaks into limbs. Net volume equals gross volume, less deduction for cull.

Hardwoods. Dicotyledonous trees, usually broad-leaved and deciduous.

Industrial wood. All roundwood products except fuelwood.

Ingrowth. The estimated net volume of growing-stock trees that became 5.0 inches dbh or larger during the period between inventories, divided by the length of the period between surveys.

International 1/4-inch rule. A log rule, or formula, for estimating the board-foot volume of logs. The mathematical formula is:

$$(0.22D^2 - 0.71D)\ (0.904762)$$

for 4-foot sections, where D = diameter inside bark at the small end of the section. This rule is used as the USDA Forest Service Standard Log rule in the Eastern United States.

Land area. (a) Bureau of Census: The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river flood plains; streams, sloughs, estuaries, and canals less than 1/8 statute mile wide; and lakes, reservoirs, and ponds less than 40 acres in area. (b) Resources Evaluation: same as (a) except that the minimum width of streams, etc., is 120 feet, and the minimum size of lakes, etc., is 1 acre.

Logging residues. The unused portions of growing-stock trees harvested or killed in the process of logging.

Manufacturing plant residues. Wood materials that are generated when converting round timber (roundwood) into wood products. This includes slabs, edgings, trimmings, bark, miscuts, sawdust, shavings, veneer cores and clippings, and pulp screening. If these residues are used, they are referred to as plant byproducts.

Miscellaneous private lands. Privately owned lands other than forest-industry and farmer-owned lands.

Mortality. The estimated net volume of growing-stock trees on the previous inventory that died from natural causes before the current inventory, divided by the length of the period between surveys.

National Forest lands. Federal lands legally designated as National Forests or purchase units and other lands administered as part of the National Forest System by the USDA Forest Service.

Noncommercial forest land. Productive-reserved, urban, and unproductive forest land.

Noncommercial species. Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Nonforest land. Land that has never supported forests, or land formerly forested but now in nonforest use such as cropland, pasture, residential areas, and highways.

Nonstocked areas. Commercial forest land that is stocked with less than 10 percent of minimum full stocking with growing-stock trees.

Plant byproducts. Wood products, such as pulp chips, recycled from manufacturing plant residues.

Poletimber stands. Stands stocked with at least 10 percent of minimum full stocking with growing-stock trees with half or more of

such stocking in poletimber or sawtimber trees or both, and in which the stocking of poletimber exceeds that of sawtimber.

Poletimber trees. Live trees of commercial species meeting regional specifications of soundness and form and at least 5.0 inches in dbh, but smaller than sawtimber trees.

Productive-reserved forest land. Forest land sufficiently productive to qualify as commercial forest land, but withdrawn from timber utilization through statute, administrative designation, or exclusive use for Christmas tree production.

Primary wood manufacturing plant. A plant that converts round timber into wood products such as woodpulp, lumber, veneer, cooperage, and dimension products.

Pulpwood. Roundwood converted into 4- or 5-foot lengths or chips, and chipped plant byproducts that are prepared for manufacture into woodpulp.

Rotten trees. Live trees of commercial species that do not contain at least one 12-foot sawlog or two noncontiguous sawlogs, each 8 feet or longer, now or prospectively, and do not meet regional specifications for freedom from defect primarily because of rot; that is, when more than 50 percent of the cull volume in a tree is rotten.

Rough trees. (a) The same as rotten trees, except that rough trees do not meet regional specifications for freedom from defect primarily because of roughness or poor form, and (b) all live trees of noncommercial species.

Roundwood products. Logs, bolts, total tree chips, or other round timber generated by harvesting trees for industrial or consumer uses.

Saplings. Live trees 1.0 through 4.9 inches dbh.

Sapling-seedling stands. Stands stocked with at least 10 percent of minimum full stocking with growing-stock trees with half or more of such stocking in saplings or seedlings or both.

Sawlog. A log meeting regional standards of diameter, length, and defect, including a minimum 8-foot length and a minimum diameter inside bark of 6 inches for softwoods and 8 inches for hardwoods.

Sawlog portion. That part of the bole of a sawtimber tree between the stump and the sawlog top; that is, the merchantable height.

Sawlog top. The point on the bole of a sawtimber tree above which a sawlog cannot be produced. The minimum sawlog top is 7.0 inches diameter outside bark (dob) for softwoods and 9.0 inches dob for hardwoods.

Sawtimber stands. Stands stocked with at least 10 percent of minimum full stocking with growing-stock trees with half or more of such stocking in poletimber or sawtimber trees or both, and in which the stocking of sawtimber is at least equal to that of poletimber.

Sawtimber trees. Live trees of commercial species at least 9.0 inches dbh for softwoods or 11.0 inches for hardwoods containing at least one 12-foot sawlog or two noncontiguous 8-foot sawlogs, and meeting regional specifications for freedom from defect.

Sawtimber volume. Net volume in board feet, International 1/4-inch rule, of sawlogs in sawtimber trees. Net volume equals gross volume less deductions for rot, sweep, and other defects that affect use for lumber.

Seedlings. Live trees less than 1.0 inch dbh that are expected to survive.

Site class. A classification of forest land in terms of inherent capacity to grow crops of industrial wood. Classifications are based on the mean annual growth of growing-stock trees attainable in fully stocked natural stands at culmination of mean annual increment.

Softwoods. Coniferous trees, usually evergreen and having needles or scalelike leaves.

Stand. A group of forest trees growing on forest land.

Stand-size class. A classification of forest land based on the size class (that is, seedlings, saplings, poletimber, or sawtimber) of growing-stock trees in the area.

Standard cord. A unit of measure for stacked bolts of wood, encompassing 128 cubic feet of wood, bark, and air space. Fuelwood cord estimates can be derived from cubic-foot estimates of growing stock by applying an average factor of 80 cubic feet of solid wood per cord. For pulpwood, a conversion of 85 cubic feet of solid wood per cord is used because of the more uniform character of pulpwood.

State lands. Lands owned by the State or leased to the State for 50 years or more.

Stocking. The degree of occupancy of land by trees, measured by basal area and/or number of trees in a stand compared to the basal area and/or number of trees required to fully use the growth potential of the land (or the stocking standard). In the Eastern United States this standard is 75 square feet of basal area per acre for trees 5.0 inches dbh and larger, or its equivalent in numbers of trees per acre for seedlings and saplings.

Two categories of stocking are used:

All live trees—these are used to classify forest land and forest types.

Growing-stock trees—these are used to classify stand-size classes.

Timber products. Manufacturing plant byproducts and roundwood (round timber) products harvested from growing-stock trees on commercial forest land; from other sources, such as cull trees, salvable dead trees, limbs, tops and saplings; and from trees on noncommercial forest and nonforest lands.

Timber removals. The growing-stock or sawtimber volumes of trees removed from the inventory for roundwood products, plus logging residues, volume destroyed during land clearing, and volume of standing trees growing on land that was reclassified from commercial forest land to noncommercial forest land.

Trees. Woody plants that have well-developed stems and are usually more than 12 feet in height at maturity.

Unproductive forest land. Forest land that is incapable of producing 20 cubic feet per acre per year of industrial wood under natural conditions, because of adverse site conditions.

Unused manufacturing residues. Plant residues that are dumped or destroyed and not recovered for plant byproducts.

Upper-stem portion. That part of the main stem or fork of a sawtimber tree above the sawlog top to a diameter of 4.0 inches outside bark or to the point where the main stem or fork breaks into limbs.

Urban forest land. Noncommercial forest land within urban areas that is completely surrounded by urban development (not parks), whether commercial, industrial, or residential.

Metric Equivalents

1 acre = 4,046.86 square meters or 0.404686 hectares

1,000 acres = 404.686 hectares

1,000,000 acres = 404,686 hectares

1,000 board feet = 3.48 cubic meters [a]

1 cubic foot = 0.028317 cubic meters

1,000 cubic feet = 28.317 cubic meters

1,000,000 cubic feet = 28,317 cubic meters

1 cord (wood, bark, and airspace) = 3.6246 cubic meters

1 cord (solid wood, pulpwood) = 2.4069 cubic meters

1 cord (solid wood, other than pulpwood) = 2.2654 cubic meters

1,000 cords (pulpwood) = 2,406.9 cubic meters

1,000 cords (other products) = 2,265.4 cubic meters

1 ton (short) = 907.1848 kilograms or 0.9071848 metric tons

1,000 tons (short) = 907.1848 metric tons

1 inch = 2.54 centimeters or 0.0254 meters

1 foot = 30.48 centimeters or 0.3048 meters

Breast height = 1.4 meters above ground level

1 mile = 1.609 kilometers

1 square foot = 929.03 square centimeters or 0.0929 square meters

1 square foot per acre basal area = 0.229568 square meters per hectare

[a] While 1,000 board feet is theoretically equivalent to 2.36 cubic meters, this is true only when a board foot is actually a piece of wood with a volume of 1/12 of 1 cubic foot. The International 1/4-inch log rule is used by the USDA Forest Service in the East to estimate the product potential in board feet. When a conversion is used, the reliability of the estimate will vary with the size of the log measure. The conversion given here, 3.48 cubic meters, is based on the cubic volume of a log 16 feet long and 15 inches in diameter inside bark (dib) at the small end. This conversion could be used for average comparisons when accuracy of 10 percent is acceptable. Since the board-foot unit is not a true measure of wood volume and since products other than dimension lumber are becoming important, this unit may eventually be phased out and replaced with the cubic-meter unit.

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Dennis, Donald F. **An analysis of Ohio's forest resources**. Broomall, PA: Northeast For. Exp. Stn.; 1983; USDA For. Serv. Resour. Bull. NE-75. 46 p.

A comprehensive analysis of the current status and trends of the forest resources of Ohio. Topics include forest area, timber volume, biomass, timber products, and growth and removals. Forest area, volume, and growth and removals are projected through 2009. Discusses water, soil, minerals, fish, wildlife, and recreation as they relate to forest resources. Also identified are forest management opportunities for increasing the production of major forest resources and enhancing the benefits derived from Ohio's forests.

Keywords: Forest survey, trends, projections, area, volume, growth, removals, nontimber forest resources, forest management opportunities.

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories are maintained at:

- Amherst, Massachusetts, in cooperation with the University of Massachusetts.
- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
- Delaware, Ohio.
- Durham, New Hampshire, in cooperation with the University of New Hampshire.
- Hamden, Connecticut, in cooperation with Yale University.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Princeton, West Virginia.
- Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
- University Park, Pennsylvania, in cooperation with the Pennsylvania State University.
- Warren, Pennsylvania.